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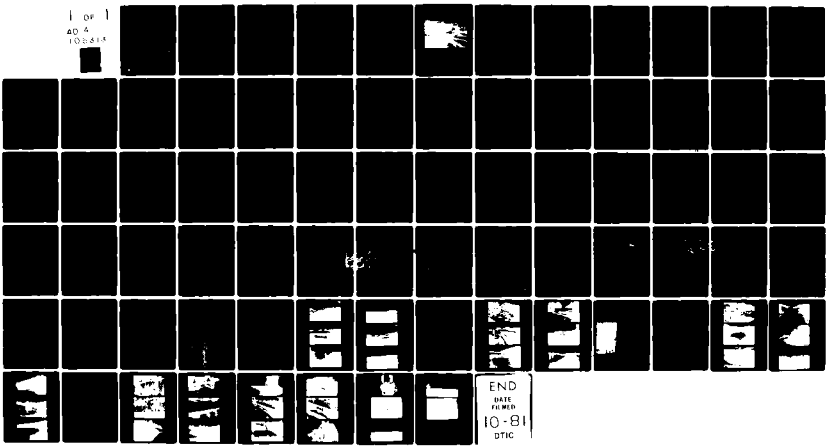

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MISSOURI-KANSAS CITY BASIN

AD A105313

FELLOWS LAKE DAM

GREENE COUNTY, MISSOURI

MO 20036

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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Corps of Engineers
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St. Louis District

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Fellows Lake Dam, MO ID No. 20036
Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Fellows Lake Dam.

It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED BY: SIGNED — Chief, Engineering Division — Date: 4 OCT 1979

APPROVED BY: SIGNED — Colonel, CE, District Engineer — Date: 4 OCT 1979

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Fellows Lake Dam
State Located	Missouri
County Located	Greene County
Stream	Little Sac River
Dates of Inspection	March 22, 1979

Fellows Lake Dam was inspected by an interdisciplinary team of engineers for Henry Reitz, under contract with the St. Louis District Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and State agencies, professional engineering organizations and private engineers. Based on these guidelines this dam is classified as a large dam with a high downstream hazard potential. The estimated damage zone from failure of the dam extends approximately 35 miles downstream from the dam.

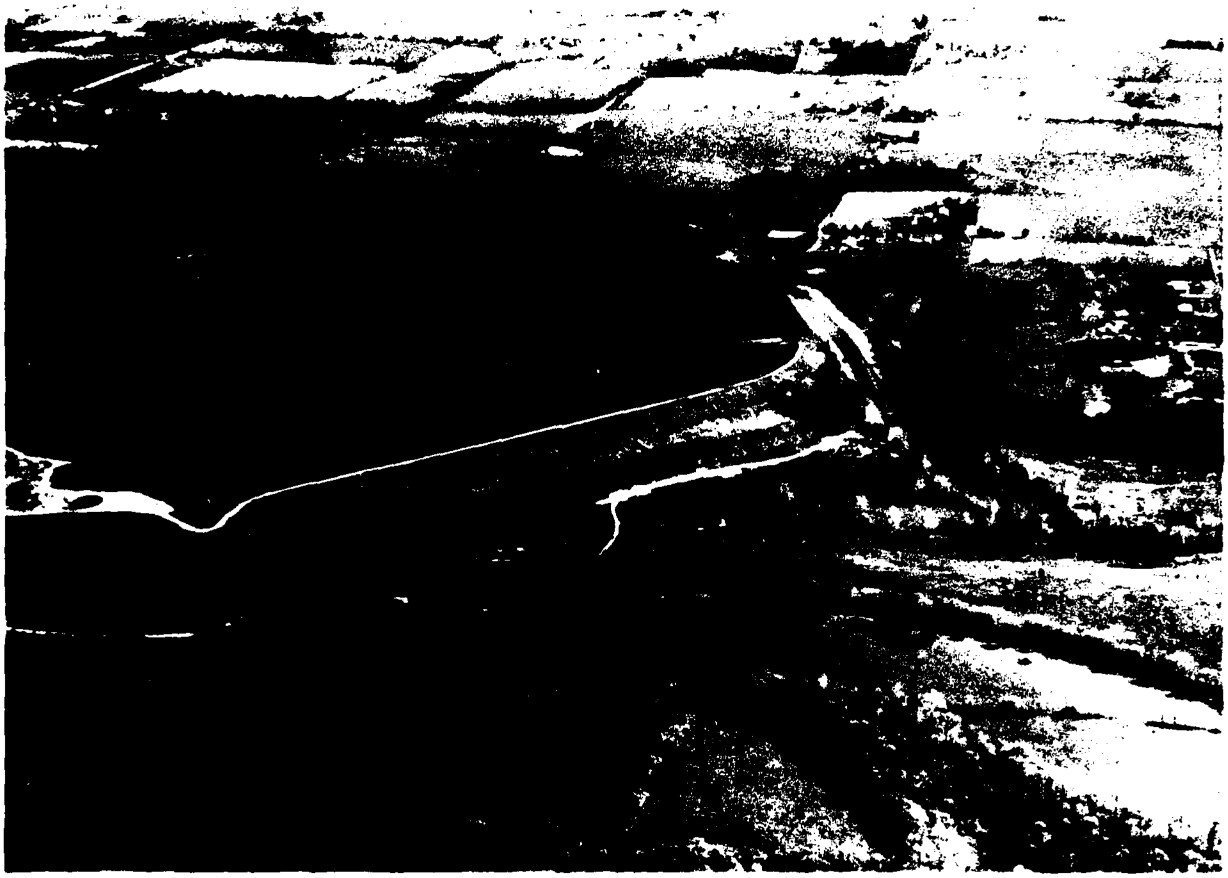
Failure would threaten approximately 30 dwellings and cause appreciable damage to commercial buildings, utilities and power lines, two highways and other secondary roads and McDaniel Lake Dam located downstream.

The guidelines for a dam having the above size and hazard potential require that the spillway be capable of passing a Probable Maximum Flood. The Probable Maximum Flood (PMF) is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions reasonably possible in the region. Considering the large volume of water impounded, the height of the dam and the hazard to downstream residences and property, the Probable Maximum Flood is the appropriate spillway design. The PMF will neither cause the lake surface to be above the top of dam nor exceed the discharge capacity of the spillway's 700 feet long weir. The concrete portion of the spillway channel is not, however, capable of containing the flow resulting from the PMF. Flows of 50% PMF and greater will begin to exceed the design spillway channel capacity which could cause considerable erosion damage to the spillway channel. The lake and spillway are adequate to contain a 1% annual probability flood (100-year flood) without exceeding the design spillway capacity.

Other deficiencies observed by the inspection team were lack of seepage and stability analyses and recurrent need for grouting. These deficiencies are further discussed in the attached report.

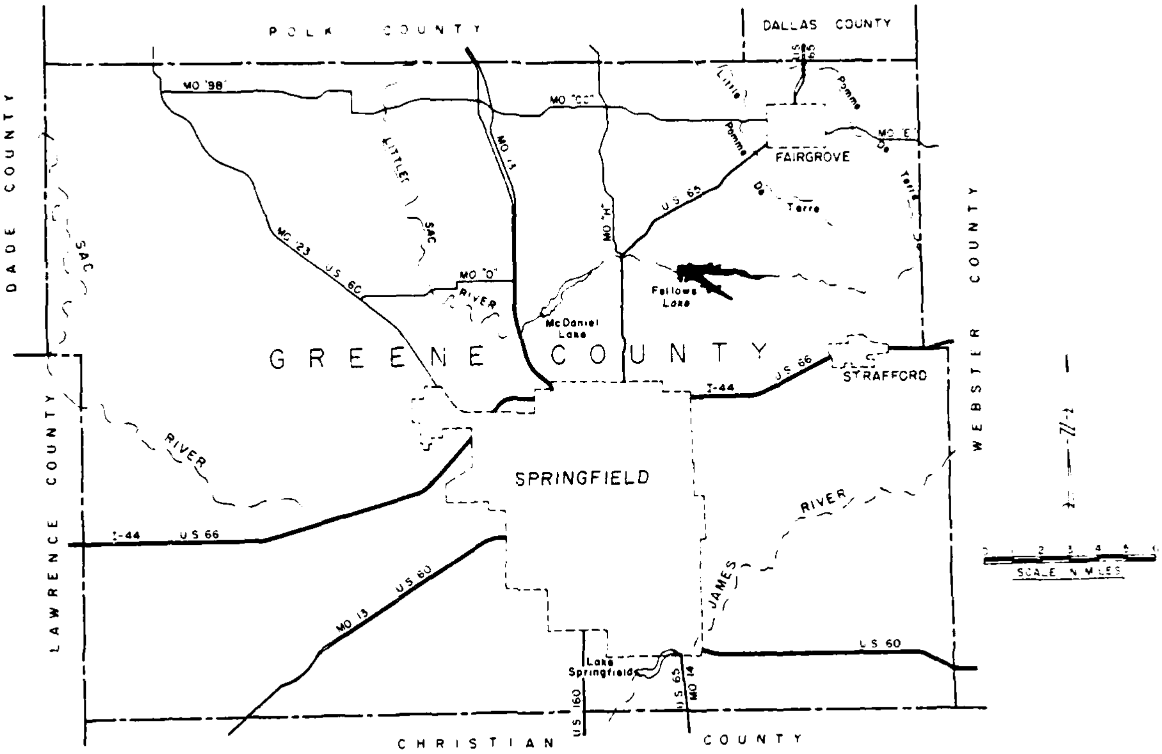
We recommend the owner take prompt action to correct or control the deficiencies described.

HENRY M. REITZ, Principal
Consulting Engineer

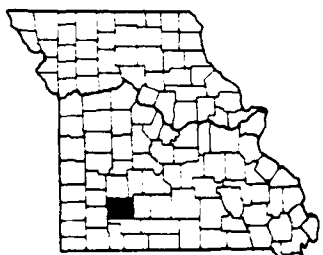


OVERVIEW-20036

PLATE I



LOCATION MAP



KEY MAP

SHOWING LOCATION OF COUNTY

PLATE 2

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
Fellows Dam, MO ID No. 20036

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer contracted with Henry Reitz (Contract DACW43-79-M-1767) for a safety inspection of the Fellows Lake Dam, MO ID No. 20036.

b. Purpose of Inspection The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed with the help of several Federal agencies and many State agencies, professional engineering organizations and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances This is a rolled impervious earth core dam approximately 1500 feet long, having a maximum height of about 100 feet. A wing dam varying in height from 10 to 25 feet extends the south end of the dam about 600 feet from the main dam to a junction with a 700-foot long concrete overflow weir into the side of a channel spillway. The axis of the main dam is on a northeast/southwest line across the valley of the Little Sac River, 4.5 miles north of Interstate 44, about six miles from the public square in Springfield, Mo. The main dam, constructed on a cement-grouted limestone foundation was completed in 1955. A diversion tunnel in the south end of the dam is an 8-foot concrete lined horseshoe section about 808 feet long.

Since the impoundment is to supplement the water supply of the City of Springfield, a 30-inch diameter cast iron draw-off pipe is constructed within the 8-foot horseshoe from a concrete plug about 50 feet from the lake end of the tunnel to the brick bulkhead at the outlet end of the tunnel. Adjacent to a trash rack at the intake end of the tunnel is a 9-foot diameter concrete intake manhole with a top elevation of 1269.5 and provision to withdraw water at elevations 1247.0, 1222.0, 1197.0 and the bottom of the tunnel, elevation 1172.0 (centerline 30-inch inlet). At the lower end of the 30-inch draw-off pipe there is a 5-foot diameter concrete control manhole constructed on the 8-foot horseshoe tunnel about 36 feet upstream of the tunnel outlet. The valves can be operated from a concrete platform at the top of the manhole which is at grade near the toe of the dam. These outlet facilities enable the City to control flows to supplement withdrawals from McDaniel Lake a few miles downstream on the Little Sac River. A steel-plate door in the downstream brick bulkhead in the 8-foot tunnel gives access for inspection of the tunnel and the 30-inch cast iron pipe draw-off. A trash rack is at the submerged entrance to the concrete tunnel.

The spillway is a concrete side channel 100 feet wide with vertical walls, 2,700-foot long crest at elevation 1260, a chute and stilling basin.

Topography in the vicinity of the dam is shown on Plate 1.

Pertinent physical data are given in paragraph 1.3 below.

b. Location The dam is located in Greene County about 4.5 miles north of the northwest corner of the City of Springfield as shown on Plate 2. The dam is in Sections 15 and 22, T30N, R21W, with the lake in Sections 13, 14, 15, 22, 23, 24, 25 and 26 of T30N, R21W and a bit of the upper end of the lake in Section 19, T30N, R20W. The lake is shown on the 1961 edition (photo-revised 1970) of the USGS 7.5 minute quadrangle Bassville (Missouri-Greene County)sheet. The topography of the watershed is on Plate 9 which is from the USGS 15 minute "Strafford" 1947 Edition.

c. Size Classification Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria this dam and impoundment are in the Large Size Category.

d. Hazard Classification Guidelines for determining hazard classification are presented in the same guidelines referenced in paragraph "c" above. Based on referenced guidelines this dam is in the High Hazard Classification.

e. Ownership The dam is owned by the City of Springfield, Mo., City Utilities, Water Department, 301 E. Central St., Jewell, P.O. Box 551, Springfield, Mo., 65801; 417-865-8311.

f. Purpose of Dam This dam forms a 751-acre lake with 26,239 acre-feet of storage below the spillway crest from contours (27,837 acre-feet record). Its principal purpose is to serve as a supplemental water supply for the City of Springfield. Controlled recreational use is permitted.

g. Design and Construction History The Water Department of City Utilities of Springfield have furnished the inspection team a set of as-built plans (31 sheets) and the Contract and Specifications prepared in 1954 by Alvord, Burdick and Howson, Engineers and Harza Engineering Co., Consultants, both of Chicago. The spillway for the dam is designed to carry a provisional flow of 25,000 cfs. The diversion tunnel was designed to have the following approximate capacities:

Depth Above Top of Tunnel	Discharge Capacity (cfs)
10	630
20	890
30	1090
50	1400
80	1780

The average annual flood was assumed to be about 1100 cfs. For design of the draw-off control valves with centerline about 1170, the maximum water level in the reservoir was assumed to be 1265.0.

The dam, spillway and outlet facilities were built as shown on the as-built plans and presumably, in accordance with the specifications.

h. Normal Operating Procedures Normal rainfall, runoff, transpiration and evaporation combine to maintain a relatively stable water surface elevation. Withdrawals are made only when downstream McDaniel Lake cannot satisfactorily fulfill the water supply needs of Springfield. The available records show the lowest lake level to have been 1252.3 on January 1 and February 1, 1965 and the highest 1260.2 on February 1, 1968 and February 1, 1969.

1.3 PERTINENT DATA

a. Drainage Area - 12,858 acres (20.09 square miles)

b. Discharge at Damsite -

(1) All discharge below the spillway crest at elevation 1260 at the damsite is through a controlled outlet manhole (supplemented by control or choice of withdrawal elevation). All spillway overflows are uncontrolled.

(2) Estimated experienced maximum flood at damsite - not available.

(3) Estimated ungated spillway capacity at maximum pool elevation - at water surface elevation 1265.0; 26,800 cfs; at water surface elevation - 1272.0; 55,800 cfs.

(4) An 800-foot long bulkheaded tunnel in virgin ground with upper flowline and lower flowline elevations of 1170 and 1168, respectively, to which a vertical lake inlet leads. The tunnel section is an 8-foot 0 inches by 8-foot 0 inches horseshoe with invert circular segment.

(5) The lake inlet drop shaft is circular, 9-foot 0 inches in diameter with top elevation 1169. The top has a grated cover.

c. Elevation (Feet Above MSL)

(1) Top of dam - 1272 feet ± (see Plate 3)

(2) Spillway crest - 1260.0

(3) Streambed at centerline of dam - 1172 feet ± (est.)

(4) Maximum tailwater - unknown

d. Reservoir Length of maximum pool - 15,800 feet ±

e. Storage (Acre-Feet) - Top of dam - 36,368 acre-feet

Spillway crest - 26,239 acre-feet

f. Reservoir Surface -

(1) Top of dam - 812 acres

(2) Spillway crest - 751 acres

g. Dam -

(1) Type - earth embankment

(2) Length - 2000 feet

(3) Height - 102 feet maximum (from flowline of Little Sac River)

(4) Top width - 20 feet

(5) Side Slopes -

(a) Downstream - 1 V on 2½ H - 10-foot berms with concrete gutters at 1240 and 1210.

(b) Upstream - 1 V on 3 H down to elevation 1240; 1 V to 3½ H below 1240.

(6) Zoning - see Section 2

(7) Impervious core - select densified earth fill.

(8) Cutoff - impervious select core carried down to rock

(9) Grout Curtain - see Section 2

h. Diversion and Regulating Tunnel 8-foot concrete lined horseshoe-shaped tunnel used for diversion; 30-inch cast iron draw-off pipe controlled with valving.

i. Spillways Concrete side overflow spillway 100 feet wide, vertical walls; 700-foot long with concrete chute and stilling basin.

j. Regulating Outlet. Selective draw-offs at four elevations with valve controlled outlet on 30-inch cast iron pipe.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

As mentioned in paragraph 1.2g the inspection team has had available the construction plans (31 sheets) and specifications prepared by the designers of the dam, Alvord, Burdick & Howson, Engineers, with Harza Engineering Co., Consultants, both headquartered in Chicago. The pertinent dimensional design information is listed in paragraph 1.3. There were also available: 1) Engineering Geologic Report on the Fellows Lake Site prepared January 10, 1975 by J.H. Williams of the Office of the Missouri State Geologist and 2) "The Geology of the Fellows Lake Area" by Thomas R. Beveridge, Missouri Geological Survey, no date.

2.2 CONSTRUCTION

The dam was constructed in 1954-1955. As the plans indicate, the rolled embankment was built in zones. The impervious cutoff fill and impervious middle section of the dam are designated as Zone 1 on the plans and were constructed of fine material such as silt, clay and earth rolled with the proper amount of moisture to form a dense impervious embankment. The plans indicate Zone 1 fill above sound rock with slopes of 1 H to 2 V up to a horizontal width of 15 feet at elevation 1265.0. The downstream section of the dam outside the limits of the Zone 1 impervious fill is shown as Zone 2 on the plans and was constructed of the coarser materials available in the excavation and borrow pits such as coarse sand and gravel mixed with broken rock. Upstream, beyond the limits of Zone 1, the plans designated the area Zone 3 and the specifications called for "coarser materials than in the impervious sections (Zone 1) but the finer sands and gravels shall be used in this portion of the work, if sufficient clay is not available".

The downstream toe of dam was constructed of broken rock or coarse gravel designated on the plans as "rip-rap". No pieces of rock were permitted weighing more than 300 pounds or less than 3 inches in any dimension.

The specifications called for exploratory drilling into the exposed rock foundation and tests for tightness. They further called for "a line of holes 25 feet apart along the centerline of the dam and each hole grouted prior to drilling the next". The depth and spacing of the holes was modified as experience dictated. The specifications further state: "The contractor shall be prepared to do as much grouting as may be required to secure a tight foundation before proceeding with the rolled fill cutoff". Prior to construction, exploratory work disclosed the presence of one or more caverns. The specifications require that "A 6-inch hole shall be drilled into any cavern discovered and the cavern filled with Class B concrete".

On the downstream face of the dam the design called for and there was built a system of concrete gutters to collect the surface water. Principal parts of these gutters were built on berms at elevations 1240 and 1210.

The 8-foot concrete horseshoe section diversion tunnel was built as shown on the plans as was the 30-inch cast iron pipe, valves and control manholes for withdrawals as required to supplement the water supply for the City of Springfield.

The overflow spillway and spillway channel were constructed of Class A concrete as called for on the plans. Underdrains were provided as shown.

2.3 OPERATION

Since construction of the dam there have been no significant dry or wet periods and the lake level has only varied between elevations 1252.3 and 1260.2 (spillway crest 1260.0).

During filling of Fellows Lake Reservoir in 1955, several localized leakage conditions developed. They were generally confined to the north and south abutments of the main and wing dam construction. Leakage was attributed primarily to existence of fractured and revised limestone strata underlying the wing dam section, spillway section and the north and south abutments. To alleviate the leakage and seepage conditions, the Water Department initiated a grouting program in 1957. The biennial report for the period ending March 31, 1973, states: "This grouting program has effectively sealed the dam from seepage and leakage and no further work has been required in recent years".

In conjunction with the grouting programs, observation holes were drilled and the Water Department since has been collecting regular (monthly) observations of water levels to ascertain any changes in seepage patterns. The inspection team has had available from the City of Springfield the weekly progress reports of the drilling and grouting in 1957. These reports indicate the City of Springfield had as consultants at one time or another on matters concerning Fellows Lake, in addition to Alvord, Burdick & Howson and Harza Engineering Co., Malcolm Pirnie Engineering, Ford, Bacon & Davis, Burns and McDonnell and A.C. Kirkwood & Assoc.

The extent of the 1957 grouting can be evaluated from the following from the Weekly Project Report No. 10 for September 29 through October 6, 1957, by R.S. LaRusso, Resident Engineer for Springfield:

Holes grouted to date	93
Permanent Curtain Holes Completed (only deep holes considered thus far)	33

Materials injected to date:

cement	21,091 bags
rock flour	22,943 C.F.
bentonite	438 bags (100#)
beet pulp	23 bags (50#)

The biennial report (period ending March 31, 1973) also states: "Riprap on the dam face and shoreline adjacent to the spillway appeared satisfactory. No evidence of shoreline erosion was observed. The overall appearance of the upstream dam access area was neat with all areas mowed and trimmed".

"Visual inspection of the intake structure, wing dam, spillway and diversion structure indicated these facilities to be in generally satisfactory condition. Observation of the diversion tunnel interior revealed it to be relatively dry with very little leakage. The present practice of periodically inspecting these structures and performing the necessary maintenance work indicated should be continued.

"Groundwater seepage from drain pipes and construction joints in the lower half of the spillway chute was observed. No turbidity in the seepage was noticed. Regular inspections of the spillway chute area for slab settlement and/or cracks resulting from abnormal seepage conditions should be continued.

"Concrete berm gutters and grass cover on the downstream side of the dam appeared to be in suitable condition. Some debris was observed in about 100 feet of the lower berm gutter near the south end of the dam and should be removed.

"Several wet areas were noted in the downstream face of the dam. These areas have existed for many years and should continue to be regularly inspected by the Water Department whenever water levels are read in the observation holes.

"The Water Department exercises control of approximately 1600 acres of land around the shoreline of Fellows Lake. All recreational uses of the impoundment and surrounding grounds are necessarily restricted to protect their use as a public water supply facility. Boating and fishing are not allowed within 300 feet of the spillway and intake structure. Boat motors are presently limited to 40 hp.

"The Water Department is continuing to add riprap along the dam's causeway road in an attempt to widen the road shoulders and control erosion. This work is accomplished randomly as riprap material becomes available from the Water Department's several construction sites."

2.4 EVALUATION

a. Availability Having access to the contract construction specifications and as-built plans for the dam, spillway and outlet facilities gives the inspection team an excellent opportunity to evaluate the dam, particularly its hydraulics and hydrology.

b. Adequacy The engineering data available while not complete do make it possible to make a reasonably detailed assessment of design, construction and operation. The owner should have an engineer, experienced in design of dams, perform detailed seepage and stability analyses.

However, from the available plans, specifications and other pertinent records, a satisfactory hydrologic/hydraulic evaluation resulted. Supplemented by the visual inspection of the dam, a defensible evaluation of the dam as a structure was feasible.

c. Validity This report is primarily for safety through maintenance and operation and the conclusions and evaluation for this Phase I Inspection are considered adequate for the definitive statement in this report. Those items of available data which could be measured within the scope of a Phase I Inspection or checked from records of other public agencies were found to be valid.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General A visual inspection of the Fellows Lake Dam was made on 22 March 1979. At that inspection the reservoir had been lowered to permit notonly routine maintenance but work along the lake edge of the spillway apron. In addition to the field inspection the records at the City of Springfield were generally reviewed and shortly thereafter, copies were received. Since as-built plans for the dam and spillway, detailed piezometer records plus biennial reports and special correspondence since completion of the lake were available, additional field inspections were not considered necessary. The inspection was made by John J. Bailey, Jr. and Henry M. Reitz, both engineers of more than 30 years' experience with formal training as Civil Engineers and professional experience in hydrology, hydraulics, soil mechanics and foundations, construction materials, surveying and structural engineering. For a Phase I report for this project, the field inspection indicated that it and the historical data supplemented by the field inspection would be sufficient.

b. Dam This is an earth dam with two intermediate berms on the downstream side primarily for maintenance reasons.

The water surface had been lowered below spillway apron to permit maintenance work. Additional test drilling was in process on the dam which was related to recent questions of underseepage.

Letter reports from the Missouri Geological Survey, June 10, 1975 and March 1, 1977 were available (see Appendix B). Reservoir and dam photos (R-1 through R-6) were taken at the general dam location. Additional photos at other portions of the reservoir were made; however, they are not considered pertinent to this Phase I Inspection report and therefore, are not referenced into it.

The nature of the upstream slope and top of dam is shown in photos R-1, R-2 and R-4. Both ends of the spillway are built into natural undisturbed terrain with the spillway set into bedrocks. Photo R-5 indicates this as well as photo W-7. The intake structure in the lake is shown on photos R-4 and R-6.

c. Spillway Apron and Weir The 700-foot long concrete weir with attached approach apron is shown in photos W-1 through W-7. Photo W-5 shows the wall at the north end of the weir, along with the nature of the bedrocks behind it. Photos W-4 and W-7 show the south end wall of the weir with the bedrock materials behind it. Photos W-2 and W-3 show the excavation from the trench for inspection and construction purposes along the reservoir side of the apron, as well as general characteristics of the concrete in the apron and the type of natural materials in the subgrade. Photo W-6 shows the lip of the weir as it projects above the apron.

d. Spillway, Channel and Chute Photos C-1 through C-9 are general pictures of the 100-foot wide by 700+ foot long concrete lined channel taking the discharge directly from the weir with increasing flow quantities from south to north, thence into the 900-foot lined chute. Photos C-2, C-4, C-5 and C-7 show the steep chute part of the channel leading into a depressed bottom

section, C-4, at the base of the slope which helps in dissipating the energy of the discharges over the spillway for an 80+ foot change in grade. Photos C-1, C-3, C-6 and C-7 show the general nature of the terrain above the concrete along the sides of the chute.

e. Masonry Deterioration Photos M-1 through M-17 indicate visible masonry surface conditions. M-1, M-2 and M-3 indicate cracking in vertical walls. From experience, the cracking is judged primarily to be the result of expansive (neither active nor at-rest) earth pressures from either the argilaceous seams in bedrock behind these walls or the backfill with these materials between the wall and the undisturbed bedrock strata. Spalling of concrete sections is indicated on photos M-5, M-7 and M-15. Scaling of concrete sections is indicated on photos M-3, M-4, M-6, M-10, M-12, M-13 and M-14 and cracking in the continuous concrete sections of the apron and weir is shown on photos M-8, M-9, M-11 and M-15.

3.2 EVALUATION

The dam, as a major portion of the water supply system of City Utilities of Springfield, Mo., has daily attention from utility personnel, visual inspections supplemented by periodic, roughly scheduled inspections, plus biennial reports. These inspections, in conjunction with the obvious indications of dam maintenance, are far better summaries of absence or presence of slides and cracking, settlement and sinkholes, erosion, burrowing animal activities and visual signs of seepage, especially since this record covers a period of approximately 25 years, albeit not completely continuous. The records are far better indication of performance and preventive maintenance than one or several visual inspections over the period in which this report was compiled.

For the essentially horizontal bedrocks in this area, which are predominantly limestones the locations of discharge downstream from the dam either directly into the channel or into outcrops, is interesting but does not affect the safety of the dam and spillway. If the main interest were to maximize storage of water behind the dam under all conditions rather than evaluate the safety of the earth dam and spillways, the role of the geology and possible change in groundwater regime would be of the same order of importance as the safety of the dam and spillway. However, since water which moves down-valley past the dam site but still reaches McDaniel Lake is available as intended and needed for the municipal water system of the City of Springfield, the emphasis of this investigation is on the stability of those structures which accumulate surface runoff and hold the general reservoir surface in Fellows Lake. Whether and/or by how much flows have been increased in the Little Sac River below the dam cannot be determined because of absence of reliable base flow information prior to construction of the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The purpose of Fellows Lake is to store water for the municipal water supply for the City of Springfield.

The reservoir may be lowered in several ways. By construction of Fellows Lake the groundwater table has been raised. Because of the bedrock characteristics at the site the higher area groundwater table has resulted in discharge at spring locations downstream. No springs are shown on USGS 7.5 minute quadrangle sheets; however, Crystal Cave is shown down-valley two miles, an indication of fissures in the bedrock which physical condition only differs in size of channel between caves and springs. The water from these springs flows to the Little Sac River and continues downstream to McDaniel Lake. A water purification plant for Springfield is located at McDaniel Lake. Since water reaching McDaniel Lake, 4 miles down-valley, is treated for the Springfield municipal water supply, a presumption of acceptable quality is logical.

Another method to lower the reservoir is by opening one or more gated openings in a vertical intake tower with top at elevation 1269 in the lake, according to plans of February 1955. This tower connects to and at the end of the tunnel beneath the dam crossing its centerline at approximately 16+75. This intake tower has 16-inch diameter gated openings at centerline elevations 1247, 1222 and 1197 plus a gated 30-inch opening at the centerline elevation 1172.

In addition to loss of water from the reservoir sides and bottoms, the lake may be drawn down by opening one or more of the valved inlets in the intake tower. From indications, none of these gate valves operates automatically; they are manual.

Discharge when the lake surface exceeds elevation 1260 will be overflow at the 700-foot long weir.

4.2 MAINTENANCE OF THE DAM

Visual inspection of the downstream surface of the dam indicated periodic mowing or cutting has controlled growth of low shrubs or anything other than grasses. This type maintenance discourages burrowing animal activity. Similar vegetative cover of the upstream slope and maintenance above the rock armor coating band straddling the level of the top of weir was observed. A road from the north across the top of the dam to a turn-around point at the north end of the spillway had rock surfacing to prevent troublesome rutting. All these appear well maintained.

On the berms on the downstream slope, Portland cement concrete paved swales have been built to concentrate flows to control indiscriminate erosion. These are also well maintained.

For the concrete surfaces of the spillway system no major maintenance appears to be needed. There had been some scaling and spalling which does not endanger the integrity of the structure but neither scaling nor spalling could easily be repaired to a completely esthetically acceptable condition. Some hairline cracking was visible in the apron and weir concrete which had been or was in the process of being repaired. Also, a trench at the reservoir edge of the apron for inspection and repair was opened in March 1979 to assure no openings were at the contact between base of slab and top of subgrade which could permit potentially destructive underseepage.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities other than those described in 4.1 and 4.2 exist. Reports do not indicate detailed maintenance records for the intake structure or the diversion tunnel. While the gates and/or valves are needed to keep available water supplied to McDaniel Lake, they do not in any reasonable sense, affect the discharge of water past the dam during periods with surface runoff.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

City Utilities has stated that it has a telephone warning plan for persons in the potential impact area of the Fellows Lake Dam. The purpose of this plan is to be able to warn persons in the area if serious danger is foreseen for physical conditions at the dam and spillway.

4.5 EVALUATION

The operational procedures described are sufficient for the needs of the existing Fellows Lake Dam and spillway.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data The project specifications state the drainage area is 20.2 square miles, that the spillway is designed for a flow of 25,000 cfs and that the annual flood is estimated to be 1000 cfs from records at McDaniel Dam downstream. No other design data was readily obtainable except what may be inferred from the project plans. The contract plans show incomplete spillway details at the lower end of the chute which were expanded and revised during construction to the configuration shown on the "as-built" plates 6, 7 and A2.

b. Experience Data The drainage area is developed from USGS Bassville and Stratford, Missouri, 1"=2000' quadrangle sheets, Editions of 1961, Photo-revised 1970. The dam, spillway and reservoir are shown on the Bassville quadrangle sheet, including contours of the reservoir area at 10-foot intervals.

There are 16-inch valves at three levels in the intake tower and tandem 30-inch valves at elevation 1172. These allow flow through a short section of the diversion tunnel to the concrete bulkhead where the 30-inch cast iron pipe carries flow under pressure to the control valves beyond the manhole at the toe of the dam.

An "as-built" plan of the intake tower in the reservoir at the upper end of the diversion tunnel was available. This shows a 30-inch cast iron pipe laid from a bulkhead in the diversion tunnel to a gate manhole near its lower end.

c. Visual Observations At the time of inspection the pool had been drawn down to about 8 feet below the spillway by use of the regulating valves in the diversion tunnel and intake tower.

(1) The spillway apron in the reservoir upstream from the weir and the weir and spillway channel pavement appear to be in good condition. Some minor maintenance of the channel pavement has been necessary. From a viewpoint of hydraulic efficiency, no significant deterioration of the pavement has occurred.

(2) The outlet works are used to supplement water supply at the waterworks facilities at McDaniel Dam downstream and are opened to supply water when unregulated flows are inadequate for demand.

(3) Between Stations 5+00 and 9+00 the west side of the spillway channel is built partially on an earth fill. This fill extends 2-1/2 feet above the concrete channel lining and has a 10-foot top width and 2H on 1V side slopes. Spillway releases appreciably above design flow will begin to overflow this berm about Station 5+00. This overflow will return to the spillway chute at about Station 9+50 or 10+00. Appreciable depth of flow over the berm, if it occurs for a sufficient length of time, could lead to degradation of the west side of the spillway channel and possibly threaten the integrity of the southern portion of the weir controlling the reservoir.

A 400-foot long level portion of the paved spillway at elevation 1165.0 ends at a 5-foot deep cutoff wall. The end of the paved spillway is about 300 feet from the toe of the dam. It does not appear that spillway releases will endanger the integrity of the dam which is protected by a rock riprap toe drain.

Spillway flows equal to design capacity could cause considerable damage to the lower end of the paved channel, in view of the velocities that would exist near the lower end of the 18% grade in the chute.

d. Overtopping Potential Hydrologic and hydraulic calculations are described in Appendix A. The design capacity of the spillway is inadequate to pass the required Probable Maximum Flood (PMF). The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydraulic conditions reasonably possible in the region. The design capacity of the spillway ·ill begin to be exceeded by a flood equal to 40% of the Probable Maximum Flood.

(1) Dam Crest If it is assumed that the spillway operates at discharges appreciably higher than design capacity, the Probable Maximum Flood will be on the verge of overtopping the dam at maximum reservoir stage and the reservoir will be within two feet of the crest of the dam for one hour. This level is 5 feet above the riprap on the upstream face of the dam.

(2) Spillway Crest Although the dam will not be overtopped if it is assumed that the spillway operates at greater than design capacity, this assumption requires that the spillway operate at or above the 25,000 cfs design capacity for a period of 6 hours during the PMF. The peak flow would be 55,000 cfs. Such flows could severely damage the west side of the spillway and possibly result in partial drainage of the reservoir depending on the extent of degradation of the spillway pavement and spillway crest apron and cutoff wall.

(3) 100-Year Flood The existing reservoir and spillway will pass a 100-year flood. The reservoir will rise a maximum of 2.8 feet during this event and peak spillway discharge will be 11,300 cfs.

(4) Impoundments in Watershed There are several dozen small impoundments in the watershed. Failure of any or all of these would not have a significant effect on the hydrologic analysis. A county road crosses the upper end of the north branch of the reservoir on a 1000-foot long fill at or slightly above the elevation of the top of dam. A large double box culvert is provided for flow through the fill. This low fill and culvert was omitted from the hydraulic analysis because it would be overtopped during the Probable Maximum Flood. Failure of this low fill would have no significant effect on the hydraulic analysis.

(5) Effect of Rupture The effect from rupture of the dam could extend approximately 35 miles downstream of the dam where approximately 30 inhabited homes downstream could be severely damaged and lives of the inhabitants could be lost should failure of the dam occur.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations Visual observations concerning the structural stability of this dam and spillway are discussed in Section 3. The dam and spillway structural stabilities are discussed separately herein since each is a major structure within itself. Each has been discussed separately in paragraphs 3.1b and 3.1c, respectively.

b. Design and Construction Data This dam has unusually good record information, starting with plans and specifications prior to construction by Alvord, Burdick & Howson, plus as-built plans showing some changes. Detailed records during construction that could indicate reasons for changes other than for obvious reasons were not found. However, the absence of discussions of changes is not felt of any consequence in evaluating the Fellows Lake Dam and spillway for Phase I Inspection. Neither analyses of dam section stability nor seepage through and under the dam were available. A seepage analysis is a necessary part of a stability analysis. Especially for the height of dam, the history of grouting and the seep line as indicated by the water surfaces in the observation holes, the lack of stability and seepage analyses is a deficiency.

c. Operating Records Biennial reports are issued in odd-numbered years on operation and maintenance by the Water Department for the City Utilities of Springfield, Mo. and were available. These reports have been prepared under contract and each has a portion which specifically concerns the Fellows Lake Dam and Reservoir. Engineering consulting offices which have worked on the Fellows Lake Dam, as it is reflected in these reports, include Burns and McDonnell and A. C. Kirkwood & Assoc. In addition to these biennial reports, correspondence indicated more detail of specific investigations, especially from Harza Engineering Co. with Malcolm Pirnie Engineers and Ford, Bacon and Davis in 1957 and Harza again, in 1977.

d. Post-Construction Changes Observations in early 1957 detected unexpected concrete cracking and appearance of water which suggested possible seepage problems. As a result, 12 "observation holes" equivalent to piezometer installations open to atmosphere were installed between Stations 14+ and 18+ on top of the dam and two berms. Readings of water surfaces in these observation holes, starting in 1961 and generally being continued to date, were made available. These readings were in several different forms; some "raw" data however, all could be used. Due to some higher observed water surfaces in 1977, six additional "observation holes" were installed at that time on the berm elevation 1210 and downslope.

Three periods of grouting, 1957, 1977 and 1979 are reported in addition to grouting during original construction. This periodic grouting is considered maintenance rather than structural modifications for the Kinderhookian Limestone bedrock characteristics at the site and is not considered unusual or alarming within itself. While this grouting was to reduce seepage, both underseepage and possibly through-seepage, it also increases structural stability of the dam section by reduction in seepage forces. A numerical evaluation of the factor of safety resulting from grouting cannot definitively be made. The riprap toe-drain shown on Plate 5 has been functioning as intended. The greater depths to the phreatic surface for the observation holes on the slope with top at 1194 than for the depths to the phreatic surface for the observation holes on berm elevation 1210 show this.

No evaluations of the soil strengths on subsurface profiles through the dam were made. A program of sampling and laboratory testing along with analysis and evaluation for which this information could be used is beyond the scope of a Phase I Inspection.

The spillway system includes a concrete approach slab, 75 feet wide, a concrete weir 700 feet long and a concrete chute with 100-foot wide bottom and varying height side wall 1600 feet long which drops 85 feet. Since construction in 1954-1955 the concrete areas have developed some scaling, hairline to minor cracking and spalling or chipping off locations. Also, in some areas, indications are that soil and/or rock surface in contact with horizontal or vertical concrete sections has not remained planar.

e. Seismic Stability A detailed seismic analysis is beyond the scope of a Phase I Inspection. None of the records available to us indicated that a seismic evaluation for the Fellows Lake Dam has been made.

Considering the seismic zone (1) in which this dam is located, even though the dam is located about midway between two fault lines aligning the east-northeast to west-southwest about 3-1/2 miles apart, a detailed seismic analysis is not considered as important as determination of the quantitative aspects of the structural stability of the dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 ASSESSMENT

a. Safety As is the case in all dam installations there is an interrelationship between spillway capacity with height and section of dam; (more particularly, the vertical distance between the control elevation of the spillway weir and the low point on top of dam). Since the Fellows Lake Dam configuration has the spillway acting as a side spill discharge into an exit channel leading to a chute, the water abruptly changes direction 90° rather than flowing in essentially a straight alignment as typical of most overflow spillway installations. For Fellows Lake Dam spillway channel capacity is equally important to weir capacity.

The Fellows Lake Dam has a spillway weir of sufficient length to discharge 100% PMF without having the reservoir elevation above the lowest point of the dam. However, the spillway channel and chute must have the surface of the rapidly flowing water above portions of the concrete sidewall protection when the discharge over the weir exceeds 40% of the PMF. The specifications state the spillway is designed for 25,000 cfs which will develop for a 40% PMF.

It is my considered opinion that at 50% of the PMF there is a probability that erosion with deterioration of the west wall of the spillway chute will begin. This location is on the other side of the spillway from the dam. It is a location at which some fill had to be placed for initial construction. Flow of 50% PMF or greater will severely damage and thereby effectively destroy the usefulness of the spillway channel and chute. It is not felt, however, that such chute damage could cause breaching of the dam.

Seepage and stability analyses have not been quantified. A program was started in 1962 and has been carried on effectively continuously with expanded coverage for determination of the surface of free water in "observation holes" at locations on the downstream face of the dam. This, in effect, is actual input on a seepage history and is more pertinent than any hypothetical analysis of the dam section with assumptions of physical properties for the zones in the fill as described in the construction documents and different assumptions of isotropic or anisotropic seepage properties of the bedrocks upon which the dam has been set.

The need for grouting within the dam area, at different times since 1957, indicates a deficiency which cannot be permanently corrected. Subsurface seep water movement along paths (all of which cannot be located) exists. Paths do exist and new ones may develop. Therefore, this changing situation is an ongoing deficiency.

Some minor cracking has been noted in concrete sections. There has also been some minor scaling and spalling from concrete surfaces. These occurrences are not considered unusual for the type, sections and age of the structure. The 1979 maintenance on the apron to the spillway weir, to assure freedom from undermining primarily along the contact between the bottom of concrete and top of rocky subgrade, is necessary and appears effective.

The cracking patterns in portions of the channel sidewalls are judged to be the result of non-uniform volume change in the backfill zone or bedrock directly behind. The argilaceous strata in the bedrock are the probable source whether used as a dense fill or exposed but not disturbed during original construction.

The history of high phreatic surface occurrences near the berm at elevation 1210 but relatively lower concurrent observations downslope suggest the "Rip Rap Toe Drain" shown on Plate 5 to be functioning as intended. The description of this toe drain in the contract specifications is incomplete to be considered a "graded filter" by current understanding. More should be known about the material gradations and if there is zoning of different size materials. This lack of information is considered a deficiency related to the seepage analysis.

b. Adequacy of Information The original contract information available for this development (approximately a quarter of a century old) plus the performance history and external visual inspection are considered sufficient data to support the conclusions herein.

Because this is a large dam, with several unusual aspects, it is necessary to continue the observations of change or fluctuation in water surfaces in observation holes, any unusual erosion or settlement in portions of the earth section and cracking and/or offset in the concrete sections on a schedule as has been the case. These data are absolutely necessary for evaluating significance of change.

c. Urgency The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. A continuous program of inspection of structures and measurement of water elevations in observation holes is essential.

d. Necessity for Phase II Based on results of the Phase I Inspection, further investigation of the actual strength of various materials in the zone dam and characteristic of the riprap toe to determine whether there has been inwash of materials by through-seepage and/or underseepage which could affect the long-term stability of the dam, are recommended.

e. Seismic Stability This dam is located in Seismic Zone 1. A detailed seismic analysis is not recommended.

7.2 REMEDIAL MEASURES

a. Alternatives The dam height and spillway weir length and elevation will not be endangered by a PMF. While the probability of damage to the spillway channel below the weir is indicated for a 50% PMF, since this will not start a sequence of erosion that will reach the dam, it is not considered a correctable deficiency.

b. Stability and Seepage Analysis The owner should have an engineer experienced in design and construction of dams prepare stability analyses for the materials used as they exist in-place and seepage patterns as they have been observed and can reasonably be anticipated.

c. Operation and Maintenance Procedures   Following O&M procedures are recommended:

(1) Continue the aggressive program of inspection of all portions of the dam and spillway as have been currently active.

(2) For the scope of coverage of these periodic observations, an engineer experienced in design, construction and maintenance of dams and related appurtenances should be aware of the history of Fellows Lake Dam and available on call.

(3) Continue maintenance repair work of minor nature as quickly as possible.

(4) The City of Springfield has indicated that it has organized a telephone warning net to alert persons in the area if extremely heavy rains occur or unusual changes are detected at the dam. This program should be kept operative.

(5) The owner should continue to keep records of observations in more detail than presently reflected in the biennial reports for City Utilities.

APPENDIX A

HYDROLOGIC & HYDRAULIC CALCULATIONS

A.1 HYDROLOGIC AND HYDRAULIC ANALYSIS METHODOLOGY

.1 The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for a reservoir routing. The Probable Maximum Precipitation for those dams in the high hazard potential category is derived and determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33". Reduction factors have not been applied. A 24-hour storm duration is assumed with the 24-hour rainfall depths distributed over 6-hour periods in accordance with procedures outlined in EM 1110-2-1411 (SPF Determination). The maximum 6-hour rainfall period is then distributed to hourly increments by the same criteria. Within-the-hour distribution is based upon NOAA Technical Memorandum NWS HYDRO-35. The non-peak 6-hour rainfall periods are distributed uniformly. All distributed values are arranged in a critical sequence by the SPF criteria. The final hydrograph is produced by deduction of infiltration losses appropriate to the soil, land use and antecedent moisture conditions.

.2 The reservoir routing is accomplished by using Modified Puls routing techniques wherein the flood hydrograph is routed through lake storage. Hydraulic capacities of the spillway and crest of dam are used as outlet controls in the routing. Storage in the pool area is defined by an elevation-area curve. The hydraulic capacity of the spillways is defined by an elevation-discharge curve (see Section A.2-3). The hydraulic capacity of the top of dam is defined by a trapezoidal broad-crested weir equation.

.3 Dam overtopping analysis has been conducted by hydrologic methods for this dam and lake. This computation determined the percentage of the PMF hydrograph that the reservoir can contain without the dam being overtopped. An output summary in the hydrologic appendix displays this information as well as other characteristics of the simulated dam overtopping.

.4 The above methodology has been accomplished for this report using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. The numeric parameters estimated for this site are listed on Plate A.1. Definitions of these variables are contained in the "User's Manual" for the computer program.

A.2.1 HYDRAULICS OF FELLOWS DAM SPILLWAY

.1 According to the Contract Documents for original construction, the spillway was designed for a discharge of 25,000 cubic feet per second. This is equivalent to using a coefficient of 6000 in the Meyers formula $Q = C\sqrt{M}$, where M is the drainage area in square miles. Flows from the Probable Maximum Flood (PMF) will be greater than the spillway design capacity. An analysis of the hydraulics of the spillway channel was made to evaluate discharge characteristics above design flows.

.2 The hydraulic control for design discharge is the capacity of the 700-foot long weir crest parallel to the outlet channel. This weir is of an unusual shape (see Plate A-2.) A discharge coefficient of 3.45 was considered appropriate. Water surface elevations in the side channel are controlled by minimum specific energy in the channel near the break in grade at Station 5+50 and friction and momentum losses above the control section. The weir discharge enters the side channel at a right angle to the direction of flow down the channel. There are appreciable energy and momentum losses in the direction of flow down the channel because of the impact of weir flow on the mass of water moving down the channel (see Ref. 1). Water surface profiles in the spillway channel were calculated using the Hydrologic Engineering Center Program HEC-2 with cross-sections at 100-foot intervals. As discharge increases, critical depth control moves downstream. Several sections were inserted between Stations 7+00 and 5+00 to locate this critical depth control with better precision. Calculated profiles in the channel using constant discharge along the weir and an energy loss coefficient of 0.5 indicates that the weir will not be appreciably affected by submergence at 25,000 cfs. Submergence of the weir along the uppermost portion of the channel does begin at flows slightly greater than 25,000 cfs. This is a flow equal to about twice the outflow of a 100-year rainfall.

.3 In order to extend the rating curve of the spillway to allow routing of the PMF, which requires outflows more than twice spillway design discharge, calculations of water surface profiles in the channel were made on the basis of a parabolic variation of discharge between Stations 0+00 and 5+00 and a linear relationship from Stations 5+00 and 7+00 for total channel discharges of 25,000 cfs to 65,000 cfs. No corrections were made for variation of discharge between Stations 5+00 and 7+00 versus actual energy grade in the reservoir. The effect on the flood routing would be minimal.

.4 At 25,000 cfs two feet freeboard below the top of concrete channel lining would exist at Station 5+00. The calculated profiles also indicate that one foot overtopping of the channel lining at Station 5+00 will occur at a spillway discharge of 35,000 cfs. At a discharge of 45,000 cfs the 10-foot earth berm will be overtopped one foot and at 55,000 cfs the earth berm may be overtopped by three or four feet. Longitudinal velocities are calculated to be in excess of 10 feet per second. Velocities at the lower end of the steep chute would be 60 to 70 feet per second for flows over 10,000 cfs.

Ref. 1: Hinds, Julian, "Side Channel Spillways, Hydraulic Theory Economic Factors and Experimental Determination of Losses", Transactions ASCE, Vol. 89, p. 881 (1926).

A.3.1 HYDROLOGY

Soils in the watershed are estimated to average as Hydrologic Soil Group C. Land use in the watershed appears to be 30% woods, 30% cropland and 40% pasture.

The SCS curve number for antecedent moisture Condition II was estimated as 76 and for Condition III as 89. Lag times were calculated from equation 15.4 of the SCS Hydrology Handbook.

The watershed consists of two main branches and some area more or less directly tributary to the reservoir. For purposes of this investigation, four hydrographs of inflow were computed, combined and routed. One hydrograph was calculated for 5.52 square miles tributary at the upper end of the south arm of the reservoir. Another was calculated for 7.37 square miles tributary at the upper end of the north branch of the reservoir. The remaining 7.2 square miles was divided into equal parts, one containing the 1.17 square mile reservoir and the areas directly tributary to the reservoir and the other representing the remaining local tributary area. These four hydrographs were combined and routed through the reservoir. A lag time of 0.35 hours was used for the directly tributary area to avoid error messages in the computer program.

It was assumed that flow through the length of the reservoir would not take any appreciable time. As a rough check, flows for the 100-year storm were compared with the 100-year flow estimated for Big Buffalo Creek (20.4 square miles) by the Kansas City District, Corps of Engineers. It was found that the peak of combined hydrograph for Fellows Lake was somewhat in excess of that for Big Buffalo Creek, which should be the case since inflow to the reservoir rather than flow at the damsite had been calculated.

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*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  3 AUG 78
*********************************
A1       ********** FELLOWS DAM SPRINGFIELD MO. **********
A2                    PROBABLE MAXIMUM FLOOD
A3
B     144       0      10      -0      -0      -0      -0      -0      -4      -0
I       5
J       1       4       1
J1    0.4     0.5     0.9     1.0
K       0   SOUTH                       1       3       1
I       INFLOW HYDROGRAPH SOUTH BRANCH
M       1       2    5.52                       1                       1
P            26.8      99     115     123
T                                                      -1     -89            0.02
W2           1.50
X    -6.4   -0.10     2.0
K       0   NORTH                       1       3       1
I       INFLOW HYDROGRAPH NORTH BRANCH
M       1       2    7.37                       1                       1
P            26.8      99     115     123
T                                                      -1     -89            0.02
W2           1.75
X    -6.4   -0.10     2.0
K       0     LCL                       1       3       1
I       INFLOW HYDROGRAPH LOCAL TRIBUTARY AREA
M       1       2    3.60                       1                       1
P            26.8      99     115     123
T                                                      -1     -89            0.02
W2           0.66
X    -1.3   -0.10     2.0
K       0   DIRCT                       1       3       1
I       INFLOW HYDROGRAPH DIRECTLY TRIBUTARY AREAS
M       1       2    3.60                       1                       1
P            26.8      99     115     123
T                                                      -1     -89            0.34
W2           0.35
X    -0.1   -0.10     2.0
K       4    COMB                       1       2       1
I       COMBINED HYDROGRAPH OF INFLOW
K       1     DAM                       2       2       1
I       ROUTING THROUGH RESERVOIR @ OVER SPILLWAY
Y                               1       1
Y1      1                                         -1260.5      -1
Y41260.0 1260.01 1260.05 1260.10 1260.20 1260.50 1261.00 1261.50 1262.00 1263.00
Y41264.0  1265.0  1266.0  1267.0  1268.0  1269.0  1270.0  1271.0  1272.0  1274.0
Y5    0.0     2.4    27.0    76.0   216.0   854.0  2415.0  4437.0  6831.0 12550.0
Y519320.  26500.  32000.  36000.  41000.  45000.  48200.  53200.  56800.  64000.
$A     0.     17.     51.    120.    221.    314.    412.    504.    624.    751.
$A   904.   1212.
$E   1170    1180    1190    1200    1210    1220    1230    1240    1250    1260
$E   1270    1280
$$1260.0

$D 1272.     2.8     1.5   2000.
K      99
```

PLATE A-1
Sheet 1 of 10

```
                         PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

                              RUNOFF HYDROGRAPH AT          SOUTH
                              RUNOFF HYDROGRAPH AT          NORTH
                              RUNOFF HYDROGRAPH AT            LCL
                              RUNOFF HYDROGRAPH AT          DIRCT
                              COMBINE  4 HYDROGRAPHS AT      COMB
                              ROUTE HYDROGRAPH TO             DAM
                              END OF NETWORK

*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION  3 AUG 78
*********************************

RUN  DATE0 09/12/79.
     TIME0 10.40.18.

                       ********** FELLOWS DAM SPRINGFIELD MO. **********
                                  PROBABLE MAXIMUM FLOOD

                                          JOB SPECIFICATION
            NQ       NHR      NMIN      IDAY       IHR      IMIN     METRC      IPLT      IPRT     NSTAN
           144         0        10        -0        -0        -0        -0        -0        -4        -0
                                        JOPER       NWT     LROPT     TRACE
                                            5        -0        -0        -0

                                  MULTI-PLAN ANALYSES TO BE PERFORMED
                                      NPLAN= 1 NRTIO= 4 LRTIO= 1
             RTIOS=     .40     .50     .90    1.00

  **********          **********          **********          **********          **********

                                      SUB-AREA RUNOFF COMPUTATION

              INFLOW HYDROGRAPH SOUTH BRANCH
                        ISTAQ     ICOMP     IECON     ITAPE      JPLT      JPRT     INAME    ISTAGE     IAUTO
                        SOUTH         0        -0        -0         1         3         1        -0        -0

                                             HYDROGRAPH DATA
```

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH SOUTH BRANCH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	IPRT	INAME	ISTAGE	IAUTO
SOUTH	0	-0	-0	1	3	1	-0	-0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	5.52	-0.00	5.52	1.00	-0.000	-0	1	-0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
-0.00	26.80	94.00	115.00	123.00	-0.00	-0.00	-0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
-0	-0.00	-0.00	1.00	-0.00	-0.00	1.00	-1.00	-89.00	-0.00	.02

CURVE NO = -89.00 WETNESS = -1.00 EFFECT CN = 89.00

UNIT HYDROGRAPH DATA
TC= -0.00 LAG= 1.50

RECESSION DATA
STRTQ= -6.40 QRCSN= -.10 RTIOR= 2.00

UNIT HYDROGRAPH 47 END OF PERIOD ORDINATES, TC= -0.00 HOURS, LAG= 1.50 VOL= 1.00

57.	185.	352.	579.	877.	1198.	1451.	1610.	1677.	1677.
1610.	1493.	1358.	1191.	987.	802.	670.	562.	472.	407.
344.	290.	241.	205.	172.	146.	122.	102.	86.	73.
62.	52.	44.	37.	31.	26.	22.	19.	16.	14.
12.	10.	8.	6.	4.	3.	1.			

END-OF-PERIOD FLOW

HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
.10	1	.02	.00	.02	33.	1.01	12.10	73	.44	.43	.02	2376.
.20	2	.02	.00	.02	31.	1.01	12.20	74	.44	.43	.01	2444.
.30	3	.02	.00	.02	29.	1.01	12.30	75	.44	.43	.01	2564.
.40	4	.02	.00	.02	27.	1.01	12.40	76	.44	.43	.01	2754.
.50	5	.02	.00	.02	26.	1.01	12.50	77	.44	.43	.01	3037.
1.00	6	.02	.00	.02	25.	1.01	13.00	78	.44	.43	.01	3421.
1.10	7	.02	.00	.02	24.	1.01	13.10	79	.53	.52	.01	3889.
1.20	8	.02	.00	.02	23.	1.01	13.20	80	.53	.52	.01	4420.
1.30	9	.02	.00	.02	23.	1.01	13.30	81	.53	.52	.01	4987.
1.40	10	.02	.00	.02	22.	1.01	13.40	82	.53	.52	.01	5575.
1.50	11	.02	.00	.02	22.	1.01	13.50	83	.53	.52	.01	6170.
2.00	12	.02	.00	.02	22.	1.01	14.00	84	.53	.52	.01	6757.
2.10	13	.02	.00	.02	21.	1.01	14.10	85	.66	.66	.01	7331.
2.20	14	.02	.00	.02	22.	1.01	14.20	86	.66	.66	.01	7885.
2.30	15	.02	.00	.02	22.	1.01	14.30	87	.66	.66	.01	8403.
2.40	16	.02	.00	.02	24.	1.01	14.40	88	.66	.66	.00	8893.
2.50	17	.02	.01	.02	26.	1.01	14.50	89	.66	.66	.00	9375.
3.00	18	.02	.01	.02	29.	1.01	15.00	90	.66	.66	.00	9854.
3.10	19	.02	.01	.02	34.	1.01	15.10	91	.60	.60	.00	10323.
3.20	20	.02	.01	.02	40.	1.01	15.20	92	1.01	1.00	.01	10793.
3.30	21	.02	.01	.02	47.	1.01	15.30	93	1.81	1.81	.01	11320.
3.40	22	.02	.01	.02	55.	1.01	15.40	94	4.54	4.52	.01	12125.
3.50	23	.02	.01	.02	64.	1.01	15.50	95	1.31	1.31	.00	13267.
4.00	24	.02	.01	.01	74.	1.01	16.00	96	.81	.80	.00	14670.
4.10	25	.02	.01	.01	84.	1.01	16.10	97	.62	.62	.00	16393.
4.20	26	.02	.01	.01	94.	1.01	16.20	98	.62	.62	.00	18399.
4.30	27	.02	.01	.01	105.	1.01	16.30	99	.62	.62	.00	20397.
4.40	28	.02	.01	.01	115.	1.01	16.40	100	.62	.62	.00	21977.
4.50	29	.02	.01	.01	126.	1.01	16.50	101	.62	.62	.00	22941.
5.00	30	.02	.01	.01	136.	1.01	17.00	102	.62	.62	.00	23442.
5.10	31	.02	.01	.01	147.	1.01	17.10	103	.49	.49	.00	23432.
5.20	32	.02	.01	.01	157.	1.01	17.20	104	.49	.49	.00	23008.
5.30	33	.02	.01	.01	167.	1.01	17.30	105	.49	.49	.00	22268.
5.40	34	.02	.01	.01	176.	1.01	17.40	106	.49	.49	.00	21322.
5.50	35	.02	.01	.01	186.	1.01	17.50	107	.49	.49	.00	20151.
6.00	36	.02	.01	.01	195.	1.01	18.00	108	.49	.49	.00	18807.
6.10	37	.12	.07	.05	207.	1.01	18.10	109	.04	.04	.00	17517.
6.20	38	.12	.08	.04	226.	1.01	18.20	110	.04	.04	.00	16391.
6.30	39	.12	.08	.04	256.	1.01	18.30	111	.04	.04	.00	15344.
6.40	40	.12	.08	.03	299.	1.01	18.40	112	.04	.04	.00	14322.
6.50	41	.12	.09	.03	362.	1.01	18.50	113	.04	.04	.00	13293.
7.00	42	.12	.09	.03	446.	1.01	19.00	114	.04	.04	.00	12172.
7.10	43	.12	.09	.03	550.	1.01	19.10	115	.04	.04	.00	11004.
7.20	44	.12	.10	.02	667.	1.01	19.20	116	.04	.04	.00	9835.
7.30	45	.12	.10	.02	794.	1.01	19.30	117	.04	.04	.00	8722.
7.40	46	.12	.10	.02	925.	1.01	19.40	118	.04	.04	.00	7662.
7.50	47	.12	.10	.02	1057.	1.01	19.50	119	.04	.04	.00	6682.
8.00	48	.12	.10	.02	1185.	1.01	20.00	120	.04	.04	.00	5791.
8.10	49	.12	.10	.02	1307.	1.01	20.10	121	.04	.04	.00	4997.
8.20	50	.12	.10	.01	1421.	1.01	20.20	122	.04	.04	.00	4306.
8.30	51	.12	.11	.01	1524.	1.01	20.30	123	.04	.04	.00	3734.
8.40	52	.12	.11	.01	1615.	1.01	20.40	124	.04	.04	.00	3265.
8.50	53	.12	.11	.01	1697.	1.01	20.50	125	.04	.04	.00	2871.
9.00	54	.12	.11	.01	1771.	1.01	21.00	126	.04	.04	.00	2542.
9.10	55	.12	.11	.01	1837.	1.01	21.10	127	.04	.04	.00	2298.
9.20	56	.12	.11	.01	1897.	1.01	21.20	128	.04	.04	.00	2145.
9.30	57	.12	.11	.01	1951.	1.01	21.30	129	.04	.04	.00	2001.
9.40	58	.12	.11	.01	2000.	1.01	21.40	130	.04	.04	.00	1867.
9.50	59	.12	.11	.01	2044.	1.01	21.50	131	.04	.04	.00	1742.
10.00	60	.12	.11	.01	2084.	1.01	22.00	132	.04	.04	.00	1625.
10.10	61	.12	.11	.01	2120.	1.01	22.10	133	.04	.04	.00	1516.
10.20	62	.12	.11	.01	2152.	1.01	22.20	134	.04	.04	.00	1415.
10.30	63	.12	.11	.01	2181.	1.01	22.30	135	.04	.04	.00	1320.
10.40	64	.12	.11	.01	2207.	1.01	22.40	136	.04	.04	.00	1232.
10.50	65	.12	.11	.01	2231.	1.01	22.50	137	.04	.04	.00	1149.
11.00	66	.12	.11	.01	2253.	1.01	23.00	138	.04	.04	.00	1072.
11.10	67	.12	.11	.01	2272.	1.01	23.10	139	.04	.04	.00	1000.
11.20	68	.12	.11	.01	2290.	1.01	23.20	140	.04	.04	.00	933.
11.30	69	.12	.11	.01	2306.	1.01	23.30	141	.04	.04	.00	871.
11.40	70	.12	.11	.01	2321.	1.01	23.40	142	.04	.04	.00	846.
11.50	71	.12	.11	.01	2335.	1.01	23.50	143	.04	.04	.00	830.
12.00	72	.12	.11	.00	2347.	1.02	0.00	144	.04	.04	.00	817.
								SUM	32.96	31.55	1.41	667944.
									(837.)	(801.)	(36.)	(18914.07)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	23442.	14341.	4636.	4636.	667522.
CMS	664.	406.	131.	131.	18902.
INCHES		24.17	31.25	31.25	31.25
MM		613.86	793.69	793.69	793.69
AC-FT		7111.	9195.	9195.	9195.
THOUS CU M		8772.	11341.	11341.	11341.

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH NORTH BRANCH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
NORTH	0	-0	-0	1	3	1	-0	-0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	7.37	-0.00	7.37	1.00	-0.000	-0	1	-0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
-0.00	26.80	99.00	115.00	123.00	-0.00	-0.00	-0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
-0	-0.00	-0.00	1.00	-0.00	-0.00	1.00	-1.00	-89.00	-0.00	.02

CURVE NO = -89.00 WETNESS = -1.00 EFFECT CN = 89.00

UNIT HYDROGRAPH DATA
TC= -0.00 LAG= 1.75

RECESSION DATA
STRTQ= -6.40 QRCSN= -.10 RTIOR= 2.00

UNIT HYDROGRAPH 55 END OF PERIOD ORDINATES, TC= -0.00 HOURS, LAG= 1.75 VOL= 1.00

53.	169.	321.	517.	771.	1040.	1394.	1650.	1826.	1923.
1941.	1923.	1826.	1706.	1570.	1408.	1214.	1016.	856.	736.
632.	543.	479.	415.	359.	306.	264.	229.	197.	171.
146.	126.	107.	94.	80.	70.	60.	52.	45.	39.
33.	28.	25.	21.	19.	17.	15.	13.	11.	9.
7.	5.	4.	2.	0.					

0

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.02	.00	.02	44.	1.01	12.10	73	.44	.43	.02	3115.
1.01	.20	2	.02	.00	.02	41.	1.01	12.20	74	.44	.43	.01	3186.
1.01	.30	3	.02	.00	.02	39.	1.01	12.30	75	.44	.43	.01	3302.
1.01	.40	4	.02	.00	.02	36.	1.01	12.40	76	.44	.43	.01	3480.
1.01	.50	5	.02	.00	.02	34.	1.01	12.50	77	.44	.43	.01	3735.
1.01	1.00	6	.02	.00	.02	33.	1.01	13.00	78	.44	.43	.01	4007.
1.01	1.10	7	.02	.00	.02	31.	1.01	13.10	79	.53	.52	.01	4542.
1.01	1.20	8	.02	.00	.02	30.	1.01	13.20	80	.53	.52	.01	5088.
1.01	1.30	9	.02	.00	.02	29.	1.01	13.30	81	.53	.52	.01	5703.
1.01	1.40	10	.02	.00	.02	28.	1.01	13.40	82	.53	.52	.01	6366.
1.01	1.50	11	.02	.00	.02	28.	1.01	13.50	83	.53	.52	.01	7058.
1.01	2.00	12	.02	.00	.02	27.	1.01	14.00	84	.53	.52	.01	7773.
1.01	2.10	13	.02	.00	.02	27.	1.01	14.10	85	.66	.66	.01	8493.
1.01	2.20	14	.02	.00	.02	27.	1.01	14.20	86	.66	.66	.01	9214.
1.01	2.30	15	.02	.00	.02	27.	1.01	14.30	87	.66	.66	.01	9928.
1.01	2.40	16	.02	.00	.02	29.	1.01	14.40	88	.66	.66	.00	10625.
1.01	2.50	17	.02	.01	.02	31.	1.01	14.50	89	.66	.66	.00	11297.
1.01	3.00	18	.02	.01	.02	34.	1.01	15.00	90	.66	.66	.00	11947.
1.01	3.10	19	.02	.01	.02	38.	1.01	15.10	91	.60	.60	.00	12575.
1.01	3.20	20	.02	.01	.02	44.	1.01	15.20	92	1.01	1.00	.01	13202.
1.01	3.30	21	.02	.01	.02	51.	1.01	15.30	93	1.81	1.81	.01	13889.
1.01	3.40	22	.02	.01	.02	59.	1.01	15.40	94	4.54	4.52	.01	14832.
1.01	3.50	23	.02	.01	.02	69.	1.01	15.50	95	1.31	1.31	.00	16071.
1.01	4.00	24	.02	.01	.01	80.	1.01	16.00	96	.81	.80	.00	17523.
1.01	4.10	25	.02	.01	.01	91.	1.01	16.10	97	.62	.62	.00	19214.
1.01	4.20	26	.02	.01	.01	104.	1.01	16.20	98	.62	.62	.00	21183.
1.01	4.30	27	.02	.01	.01	117.	1.01	16.30	99	.62	.62	.00	23351.
1.01	4.40	28	.02	.01	.01	130.	1.01	16.40	100	.62	.62	.00	25444.
1.01	4.50	29	.02	.01	.01	143.	1.01	16.50	101	.62	.62	.00	27157.
1.01	5.00	30	.02	.01	.01	157.	1.01	17.00	102	.62	.62	.00	28355.
1.01	5.10	31	.02	.01	.01	171.	1.01	17.10	103	.49	.49	.00	29034.
1.01	5.20	32	.02	.01	.01	184.	1.01	17.20	104	.49	.49	.00	29223.
1.01	5.30	33	.02	.01	.01	197.	1.01	17.30	105	.49	.49	.00	29063.
1.01	5.40	34	.02	.01	.01	210.	1.01	17.40	106	.49	.49	.00	28482.
1.01	5.50	35	.02	.01	.01	223.	1.01	17.50	107	.49	.49	.00	27680.
1.01	6.00	36	.02	.01	.01	236.	1.01	18.00	108	.49	.49	.00	26694.
1.01	6.10	37	.12	.07	.05	251.	1.01	18.10	109	.04	.04	.00	25478.
1.01	6.20	38	.12	.08	.04	272.	1.01	18.20	110	.04	.04	.00	24034.
1.01	6.30	39	.12	.08	.04	303.	1.01	18.30	111	.04	.04	.00	22512.
1.01	6.40	40	.12	.08	.03	346.	1.01	18.40	112	.04	.04	.00	21074.
1.01	6.50	41	.12	.09	.03	406.	1.01	18.50	113	.04	.04	.00	19723.
1.01	7.00	42	.12	.09	.03	485.	1.01	19.00	114	.04	.04	.00	18357.
1.01	7.10	43	.12	.09	.03	587.	1.01	19.10	115	.04	.04	.00	16968.
1.01	7.20	44	.12	.10	.02	708.	1.01	19.20	116	.04	.04	.00	15587.
1.01	7.30	45	.12	.10	.02	845.	1.01	19.30	117	.04	.04	.00	14174.
1.01	7.40	46	.12	.10	.02	993.	1.01	19.40	118	.04	.04	.00	12785.
1.01	7.50	47	.12	.10	.02	1147.	1.01	19.50	119	.04	.04	.00	11441.
1.01	8.00	48	.12	.10	.02	1304.	1.01	20.00	120	.04	.04	.00	10185.
1.01	8.10	49	.12	.10	.02	1460.	1.01	20.10	121	.04	.04	.00	9034.
1.01	8.20	50	.12	.10	.01	1612.	1.01	20.20	122	.04	.04	.00	7978.
1.01	8.30	51	.12	.11	.01	1758.	1.01	20.30	123	.04	.04	.00	7025.
1.01	8.40	52	.12	.11	.01	1896.	1.01	20.40	124	.04	.04	.00	6172.
1.01	8.50	53	.12	.11	.01	2022.	1.01	20.50	125	.04	.04	.00	5440.
1.01	9.00	54	.12	.11	.01	2136.	1.01	21.00	126	.04	.04	.00	4817.
1.01	9.10	55	.12	.11	.01	2240.	1.01	21.10	127	.04	.04	.00	4298.
1.01	9.20	56	.12	.11	.01	2334.	1.01	21.20	128	.04	.04	.00	3847.
1.01	9.30	57	.12	.11	.01	2419.	1.01	21.30	129	.04	.04	.00	3463.
1.01	9.40	58	.12	.11	.01	2497.	1.01	21.40	130	.04	.04	.00	3129.
1.01	9.50	59	.12	.11	.01	2568.	1.01	21.50	131	.04	.04	.00	2866.
1.01	10.00	60	.12	.11	.01	2633.	1.01	22.00	132	.04	.04	.00	2674.
1.01	10.10	61	.12	.11	.01	2692.	1.01	22.10	133	.04	.04	.00	2495.
1.01	10.20	62	.12	.11	.01	2746.	1.01	22.20	134	.04	.04	.00	2328.
1.01	10.30	63	.12	.11	.01	2795.	1.01	22.30	135	.04	.04	.00	2172.
1.01	10.40	64	.12	.11	.01	2839.	1.01	22.40	136	.04	.04	.00	2026.
1.01	10.50	65	.12	.11	.01	2880.	1.01	22.50	137	.04	.04	.00	1891.
1.01	11.00	66	.12	.11	.01	2917.	1.01	23.00	138	.04	.04	.00	1764.
1.01	11.10	67	.12	.11	.01	2950.	1.01	23.10	139	.04	.04	.00	1646.
1.01	11.20	68	.12	.11	.01	2981.	1.01	23.20	140	.04	.04	.00	1536.
1.01	11.30	69	.12	.11	.01	3009.	1.01	23.30	141	.04	.04	.00	1433.
1.01	11.40	70	.12	.11	.01	3034.	1.01	23.40	142	.04	.04	.00	1362.
1.01	11.50	71	.12	.11	.01	3057.	1.01	23.50	143	.04	.04	.00	1310.
1.01	12.00	72	.12	.11	.00	3079.	1.02	0.00	144	.04	.04	.00	1263.
									SUM	32.96	31.55	1.41	887278.
										(837.)	(801.)	(36.)	(25124.92)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	29223.	18807.	6157.	6157.	886622.
CMS	828.	533.	174.	174.	25106.
INCHES		23.74	31.09	31.09	31.09
MM		602.95	789.58	789.58	789.58
AC-FT		9326.	12212.	12212.	12212.
THOUS CU M		11503.	15064.	15064.	15064.

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH LOCAL TRIBUTARY AREA

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
LCL	0	-0	-0	1	3	1	-0	-0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	3.60	-0.00	3.60	1.00	-0.000	-0	1	-0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
-0.00	26.80	99.00	115.00	123.00	-0.00	-0.00	-0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
-0	-0.00	-0.00	1.00	-0.00	-0.00	1.00	-1.00	-89.00	-0.00	.02

CURVE NO = -89.00 WETNESS = -1.00 EFFECT CN = 89.00

UNIT HYDROGRAPH DATA
TC= -0.00 LAG= .66

RECESSION DATA
STRTQ= -1.30 QRCSN= -.10 RTIOR= 2.00

UNIT HYDROGRAPH 22 END OF PERIOD ORDINATES, TC= -0.00 HOURS, LAG= .66 VOL= 1.00

285.	905.	1813.	2308.	2283.	1924.	1394.	921.	639.	454.
312.	218.	150.	104.	72.	50.	34.	25.	18.	12.
7.	2.								

0

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.02	.00	.02	5.	1.01	12.10	73	.44	.43	.02	1669.
1.01	.20	2	.02	.00	.02	5.	1.01	12.20	74	.44	.43	.01	1954.
1.01	.30	3	.02	.00	.02	5.	1.01	12.30	75	.44	.43	.01	2524.
1.01	.40	4	.02	.00	.02	6.	1.01	12.40	76	.44	.43	.01	3251.
1.01	.50	5	.02	.00	.02	7.	1.01	12.50	77	.44	.43	.01	3973.
1.01	1.00	6	.02	.00	.02	8.	1.01	13.00	78	.44	.43	.01	4586.
1.01	1.10	7	.02	.00	.02	8.	1.01	13.10	79	.53	.52	.01	5060.
1.01	1.20	8	.02	.00	.02	8.	1.01	13.20	80	.53	.52	.01	5441.
1.01	1.30	9	.02	.00	.02	8.	1.01	13.30	81	.53	.52	.01	5813.
1.01	1.40	10	.02	.00	.02	8.	1.01	13.40	82	.53	.52	.01	6169.
1.01	1.50	11	.02	.00	.02	9.	1.01	13.50	83	.53	.52	.01	6479.
1.01	2.00	12	.02	.00	.02	9.	1.01	14.00	84	.53	.52	.01	6727.
1.01	2.10	13	.02	.00	.02	10.	1.01	14.10	85	.66	.66	.01	6945.
1.01	2.20	14	.02	.00	.02	13.	1.01	14.20	86	.66	.66	.01	7187.
1.01	2.30	15	.02	.00	.02	17.	1.01	14.30	87	.66	.66	.01	7514.
1.01	2.40	16	.02	.00	.02	24.	1.01	14.40	88	.66	.66	.00	7882.
1.01	2.50	17	.02	.01	.02	31.	1.01	14.50	89	.66	.66	.00	8229.
1.01	3.00	18	.02	.01	.02	39.	1.01	15.00	90	.66	.66	.00	8517.
1.01	3.10	19	.02	.01	.02	48.	1.01	15.10	91	.60	.60	.00	8710.
1.01	3.20	20	.02	.01	.02	57.	1.01	15.20	92	1.01	1.00	.01	8913.
1.01	3.30	21	.02	.01	.02	65.	1.01	15.30	93	1.81	1.81	.01	9498.
1.01	3.40	22	.02	.01	.02	74.	1.01	15.40	94	4.54	4.52	.01	11662.
1.01	3.50	23	.02	.01	.02	82.	1.01	15.50	95	1.31	1.31	.00	15505.
1.01	4.00	24	.02	.01	.01	90.	1.01	16.00	96	.81	.80	.00	20069.
1.01	4.10	25	.02	.01	.01	98.	1.01	16.10	97	.62	.62	.00	22550.
1.01	4.20	26	.02	.01	.01	105.	1.01	16.20	98	.62	.62	.00	22317.
1.01	4.30	27	.02	.01	.01	112.	1.01	16.30	99	.62	.62	.00	20167.
1.01	4.40	28	.02	.01	.01	119.	1.01	16.40	100	.62	.62	.00	17164.
1.01	4.50	29	.02	.01	.01	125.	1.01	16.50	101	.62	.62	.00	14474.
1.01	5.00	30	.02	.01	.01	132.	1.01	17.00	102	.62	.62	.00	12668.
1.01	5.10	31	.02	.01	.01	138.	1.01	17.10	103	.49	.49	.00	11419.
1.01	5.20	32	.02	.01	.01	143.	1.01	17.20	104	.49	.49	.00	10427.
1.01	5.30	33	.02	.01	.01	149.	1.01	17.30	105	.49	.49	.00	9587.
1.01	5.40	34	.02	.01	.01	154.	1.01	17.40	106	.49	.49	.00	8857.
1.01	5.50	35	.02	.01	.01	159.	1.01	17.50	107	.49	.49	.00	8263.
1.01	6.00	36	.02	.01	.01	164.	1.01	18.00	108	.49	.49	.00	7807.
[illegible]	[illegible]	37	.12	[illegible]	[illegible]	184.	1.01	18.10	109	.04	.04	.00	[illegible]
1.01	6.20	38	.12	.08	.04	241.	1.01	18.20	110	.04	.04	.00	6728.
1.01	6.30	39	.12	.08	.04	354.	1.01	18.30	111	.04	.04	.00	5764.
1.01	6.40	40	.12	.08	.03	503.	1.01	18.40	112	.04	.04	.00	4622.
1.01	6.50	41	.12	.09	.03	661.	1.01	18.50	113	.04	.04	.00	3514.
1.01	7.00	42	.12	.09	.03	806.	1.01	19.00	114	.04	.04	.00	2586.
1.01	7.10	43	.12	.09	.03	926.	1.01	19.10	115	.04	.04	.00	2178.
1.01	7.20	44	.12	.10	.02	1021.	1.01	19.20	116	.04	.04	.00	2032.
1.01	7.30	45	.12	.10	.02	1099.	1.01	19.30	117	.04	.04	.00	1896.
1.01	7.40	46	.12	.10	.02	1164.	1.01	19.40	118	.04	.04	.00	1769.
1.01	7.50	47	.12	.10	.02	1218.	1.01	19.50	119	.04	.04	.00	1651.
1.01	8.00	48	.12	.10	.02	1263.	1.01	20.00	120	.04	.04	.00	1540.
1.01	8.10	49	.12	.10	.02	1302.	1.01	20.10	121	.04	.04	.00	1437.
1.01	8.20	50	.12	.10	.01	1335.	1.01	20.20	122	.04	.04	.00	1341.
1.01	8.30	51	.12	.11	.01	1363.	1.01	20.30	123	.04	.04	.00	1251.
1.01	8.40	52	.12	.11	.01	1388.	1.01	20.40	124	.04	.04	.00	1167.
1.01	8.50	53	.12	.11	.01	1409.	1.01	20.50	125	.04	.04	.00	1089.
1.01	9.00	54	.12	.11	.01	1428.	1.01	21.00	126	.04	.04	.00	1016.
1.01	9.10	55	.12	.11	.01	1445.	1.01	21.10	127	.04	.04	.00	948.
1.01	9.20	56	.12	.11	.01	1460.	1.01	21.20	128	.04	.04	.00	885.
1.01	9.30	57	.12	.11	.01	1474.	1.01	21.30	129	.04	.04	.00	825.
1.01	9.40	58	.12	.11	.01	1486.	1.01	21.40	130	.04	.04	.00	770.
1.01	9.50	59	.12	.11	.01	1496.	1.01	21.50	131	.04	.04	.00	719.
1.01	10.00	60	.12	.11	.01	1506.	1.01	22.00	132	.04	.04	.00	670.
1.01	10.10	61	.12	.11	.01	1515.	1.01	22.10	133	.04	.04	.00	626.
1.01	10.20	62	.12	.11	.01	1523.	1.01	22.20	134	.04	.04	.00	584.
1.01	10.30	63	.12	.11	.01	1530.	1.01	22.30	135	.04	.04	.00	545.
1.01	10.40	64	.12	.11	.01	1537.	1.01	22.40	136	.04	.04	.00	508.
1.01	10.50	65	.12	.11	.01	1543.	1.01	22.50	137	.04	.04	.00	497.
1.01	11.00	66	.12	.11	.01	1549.	1.01	23.00	138	.04	.04	.00	497.
1.01	11.10	67	.12	.11	.01	1555.	1.01	23.10	139	.04	.04	.00	497.
1.01	11.20	68	.12	.11	.01	1560.	1.01	23.20	140	.04	.04	.00	497.
1.01	11.30	69	.12	.11	.01	1564.	1.01	23.30	141	.04	.04	.00	497.
1.01	11.40	70	.12	.11	.01	1569.	1.01	23.40	142	.04	.04	.00	497.
1.01	11.50	71	.12	.11	.01	1573.	1.01	23.50	143	.04	.04	.00	497.
1.01	12.00	72	.12	.11	.00	1576.	1.02	0.00	144	.04	.04	.00	497.
									SUM	32.96	31.55	1.41	447328.
										(837.)	(801.)	(36.)	(12666.92)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	22550.	9856.	3105.	3105.	447081.
CMS	639.	279.	88.	88.	12660.
INCHES		25.47	32.09	32.09	32.09
MM		646.88	815.09	815.09	815.09
AC-FT		4887.	6158.	6158.	6158.
THOUS CU M		6028.	7596.	7596.	7596.

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH DIRECTLY TRIBUTARY AREAS

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
DIRCT	0	-0	-0	1	3	1	-0	-0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	3.60	-0.00	3.60	1.00	-0.000	-0	1	-0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
-0.00	26.80	99.00	115.00	123.00	-0.00	-0.00	-0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
-0	-0.00	-0.00	1.00	-0.00	-0.00	1.00	-1.00	-89.00	-0.00	.34

CURVE NO = -89.00 WETNESS = -1.00 EFFECT CN = 89.00

UNIT HYDROGRAPH DATA
TC= -0.00 LAG= .35

RECESSION DATA
STRTQ= -.10 QRCSN= -.10 RTIOR= 2.00

UNIT HYDROGRAPH 12 END OF PERIOD ORDINATES, TC= -0.00 HOURS, LAG= .35 VOL= 1.00
1171. 3601. 3848. 2547. 1280. 702. 374. 198. 107. 57.
33. 15.

0

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.02	.01	.02	10.	1.01	12.10	73	.44	.43	.01	1981.
1.01	.20	2	.02	.01	.02	39.	1.01	12.20	74	.44	.43	.01	3119.
1.01	.30	3	.02	.01	.02	70.	1.01	12.30	75	.44	.43	.01	4339.
1.01	.40	4	.02	.01	.02	91.	1.01	12.40	76	.44	.43	.01	5153.
1.01	.50	5	.02	.01	.02	101.	1.01	12.50	77	.44	.44	.01	5569.
1.01	1.00	6	.02	.01	.02	107.	1.01	13.00	78	.44	.44	.01	5802.
1.01	1.10	7	.02	.01	.02	110.	1.01	13.10	79	.53	.52	.01	6034.
1.01	1.20	8	.02	.01	.02	111.	1.01	13.20	80	.53	.52	.01	6421.
1.01	1.30	9	.02	.01	.02	112.	1.01	13.30	81	.53	.53	.01	6801.
1.01	1.40	10	.02	.01	.02	113.	1.01	13.40	82	.53	.53	.00	7050.
1.01	1.50	11	.02	.01	.02	113.	1.01	13.50	83	.53	.53	.00	7181.
1.01	2.00	12	.02	.01	.02	114.	1.01	14.00	84	.53	.53	.00	7255.
1.01	2.10	13	.02	.01	.01	117.	1.01	14.10	85	.66	.66	.00	7448.
1.01	2.20	14	.02	.01	.01	122.	1.01	14.20	86	.66	.66	.00	7946.
1.01	2.30	15	.02	.01	.01	128.	1.01	14.30	87	.66	.66	.00	8468.
1.01	2.40	16	.02	.01	.01	135.	1.01	14.40	88	.66	.66	.00	8814.
1.01	2.50	17	.02	.01	.01	141.	1.01	14.50	89	.66	.66	.00	8991.
1.01	3.00	18	.02	.01	.01	148.	1.01	15.00	90	.66	.66	.00	9090.
1.01	3.10	19	.02	.01	.01	154.	1.01	15.10	91	.60	.60	.00	9075.
1.01	3.20	20	.02	.01	.01	160.	1.01	15.20	92	1.01	1.00	.00	9366.
1.01	3.30	21	.02	.01	.01	166.	1.01	15.30	93	1.81	1.81	.01	11549.
1.01	3.40	22	.02	.01	.01	171.	1.01	15.40	94	4.54	4.53	.01	19038.
1.01	3.50	23	.02	.01	.01	176.	1.01	15.50	95	1.31	1.31	.00	29105.
1.01	4.00	24	.02	.01	.01	181.	1.01	16.00	96	.81	.81	.00	29909.
1.01	4.10	25	.02	.01	.01	186.	1.01	16.10	97	.62	.62	.00	23705.
1.01	4.20	26	.02	.01	.01	190.	1.01	16.20	98	.62	.62	.00	17079.
1.01	4.30	27	.02	.01	.01	195.	1.01	16.30	99	.62	.62	.00	13241.
1.01	4.40	28	.02	.01	.01	199.	1.01	16.40	100	.62	.62	.00	11078.
1.01	4.50	29	.02	.02	.01	203.	1.01	16.50	101	.62	.62	.00	9925.
1.01	5.00	30	.02	.02	.01	207.	1.01	17.00	102	.62	.62	.00	9317.
1.01	5.10	31	.02	.02	.01	210.	1.01	17.10	103	.49	.49	.00	8836.
1.01	5.20	32	.02	.02	.01	214.	1.01	17.20	104	.49	.49	.00	8189.
1.01	5.30	33	.02	.02	.01	217.	1.01	17.30	105	.49	.49	.00	7567.
1.01	5.40	34	.02	.02	.01	220.	1.01	17.40	106	.49	.49	.00	7153.
1.01	5.50	35	.02	.02	.01	223.	1.01	17.50	107	.49	.49	.00	6969.
1.01	6.00	36	.02	.02	.01	226.	1.01	18.00	~~108~~	~~.49~~	~~.49~~	~~.00~~	6874.
1.01	6.10	37	.12	.09	.03	310.	1.01	18.10	109	.04	.04	.00	6297.
1.01	6.20	38	.12	.09	.03	566.	1.01	18.20	110	.04	.04	.00	4650.
1.01	6.30	39	.12	.09	.03	851.	1.01	18.30	111	.04	.04	.00	2981.
1.01	6.40	40	.12	.10	.02	1057.	1.01	18.40	112	.04	.04	.00	2781.
1.01	6.50	41	.12	.10	.02	1180.	1.01	18.50	113	.04	.04	.00	2595.
1.01	7.00	42	.12	.10	.02	1263.	1.01	19.00	114	.04	.04	.00	2421.
1.01	7.10	43	.12	.10	.02	1320.	1.01	19.10	115	.04	.04	.00	2259.
1.01	7.20	44	.12	.10	.02	1362.	1.01	19.20	116	.04	.04	.00	2108.
1.01	7.30	45	.12	.10	.01	1395.	1.01	19.30	117	.04	.04	.00	1967.
1.01	7.40	46	.12	.11	.01	1421.	1.01	19.40	118	.04	.04	.00	1835.
1.01	7.50	47	.12	.11	.01	1443.	1.01	19.50	119	.04	.04	.00	1712.
1.01	8.00	48	.12	.11	.01	1462.	1.01	20.00	120	.04	.04	.00	1597.
1.01	8.10	49	.12	.11	.01	1477.	1.01	20.10	121	.04	.04	.00	1490.
1.01	8.20	50	.12	.11	.01	1491.	1.01	20.20	122	.04	.04	.00	1391.
1.01	8.30	51	.12	.11	.01	1503.	1.01	20.30	123	.04	.04	.00	1297.
1.01	8.40	52	.12	.11	.01	1514.	1.01	20.40	124	.04	.04	.00	1211.
1.01	8.50	53	.12	.11	.01	1524.	1.01	20.50	125	.04	.04	.00	1130.
1.01	9.00	54	.12	.11	.01	1532.	1.01	21.00	126	.04	.04	.00	1054.
1.01	9.10	55	.12	.11	.01	1540.	1.01	21.10	127	.04	.04	.00	983.
1.01	9.20	56	.12	.11	.01	1548.	1.01	21.20	128	.04	.04	.00	917.
1.01	9.30	57	.12	.11	.01	1554.	1.01	21.30	129	.04	.04	.00	856.
1.01	9.40	58	.12	.11	.01	1560.	1.01	21.40	130	.04	.04	.00	799.
1.01	9.50	59	.12	.11	.01	1566.	1.01	21.50	131	.04	.04	.00	745.
1.01	10.00	60	.12	.11	.01	1571.	1.01	22.00	132	.04	.04	.00	695.
1.01	10.10	61	.12	.11	.01	1576.	1.01	22.10	133	.04	.04	.00	649.
1.01	10.20	62	.12	.11	.01	1580.	1.01	22.20	134	.04	.04	.00	605.
1.01	10.30	63	.12	.11	.00	1584.	1.01	22.30	135	.04	.04	.00	565.
1.01	10.40	64	.12	.11	.00	1588.	1.01	22.40	136	.04	.04	.00	527.
1.01	10.50	65	.12	.11	.00	1591.	1.01	22.50	137	.04	.04	.00	497.
1.01	11.00	66	.12	.11	.00	1594.	1.01	23.00	138	.04	.04	.00	497.
1.01	11.10	67	.12	.12	.00	1597.	1.01	23.10	139	.04	.04	.00	497.
1.01	11.20	68	.12	.12	.00	1600.	1.01	23.20	140	.04	.04	.00	497.
1.01	11.30	69	.12	.12	.00	1603.	1.01	23.30	141	.04	.04	.00	497.
1.01	11.40	70	.12	.12	.00	1605.	1.01	23.40	142	.04	.04	.00	497.
1.01	11.50	71	.12	.12	.00	1607.	1.01	23.50	143	.04	.04	.00	497.
1.01	12.00	72	.12	.12	.00	1609.	1.02	0.00	144	.04	.04	.00	497.
									SUM	32.96	32.01	.95	464054.
										(837.)	(813.)	(24.)	(13140.55)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	29909.	10017.	3221.	3221.	463803.
CMS	847.	284.	91.	91.	13133.
INCHES		25.88	33.29	33.29	33.29
MM		657.44	845.58	845.58	845.58
AC-FT		4967.	6388.	6388.	6388.
THOUS CU M		6127.	7880.	7880.	7880.

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                                    COMBINE HYDROGRAPHS

                  COMBINED HYDROGRAPH OF INFLOW
                          ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                           COMB       4      -0      -0       1       2       1      -0      -0


                          SUM OF 4 HYDROGRAPHS AT    COMB  PLAN 1  RTIO 1
     91.      116.      143.      160.      168.      172.      173.      173.      172.      172.
    171.      172.      176.      184.      195.      211.      229.      251.      275.      301.
    329.      360.      392.      425.      459.      494.      528.      563.      598.      632.
    665.      698.      730.      761.      791.      820.      952.     1305.     1764.     2206.
   2609.     3001.     3383.     3759.     4133.     4503.     4864.     5214.     5546.     5859.
   6148.     6412.     6652.     6868.     7062.     7239.     7398.     7543.     7674.     7794.
   7902.     8001.     8090.     8171.     8245.     8313.     8374.     8430.     8482.     8529.
   8572.     8611.     9140.    10702.    12729.    14637.    16314.    17896.    19525.    21370.
  23303.    25161.    26888.    28512.    30217.    32232.    34313.    36215.    37892.    39407.
  40683.    42274.    46256.    57657.    73947.    82171.    81862.    78978.    77157.    75664.
  74547.    73783.    72722.    70847.    68485.    65814.    63063.    60182.    56647.    51803.
  46601.    42799.    39125.    35536.    32414.    29563.    26760.    24051.    21486.    19114.
  16958.    15016.    13307.    11815.    10531.     9428.     8528.     7794.     7145.     6565.
   6071.     5665.     5285.     4931.     4601.     4293.     4034.     3831.     3641.     3464.
   3298.     3203.     3134.     3075.

                                PEAK    6-HOUR   24-HOUR   72-HOUR   TOTAL VOLUME
                       CFS    82171.    51601.    17118.    17118.       2465028.
                       CMS     2327.     1461.      485.      485.         69802.
                    INCHES               23.89     31.71     31.71          31.71
                        MM              606.88    805.31    805.31         805.31
                     AC-FT              25587.    33954.    33954.         33954.
                THOUS CU M              31561.    41881.    41881.         41881.

 **********          **********          **********          **********          **********

                                    HYDROGRAPH ROUTING

                  ROUTING THROUGH RESERVOIR & OVER SPILLWAY
                          ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                            DAM       1      -0      -0       2       2       1      -0      -0
                                                 ROUTING DATA
                  QLOSS   CLOSS     AVG    IRES   ISAME    IOPT    IPMP                  LSTR
                   -0.0  -0.000   -0.00       1       1      -0      -0                    -0

                          NSTPS   NSTDL     LAG   AMSKK       X     TSK   STORA  ISPRAT
                              1      -0      -0  -0.000  -0.000  -0.000  -1260.      -1

     STAGE     1260.0     1260.0     1260.1     1260.1     1260.2     1260.5     1261.0     1261.5     1262.0     1263.
               1264.0     1265.0     1266.0     1267.0     1268.0     1269.0     1270.0     1271.0     1272.0     1274.

      FLOW         0.         2.        27.        76.       216.       854.      2415.      4437.      6831.     12550
               14320.     26500.     32000.     36000.     41000.     45000.     48200.     53200.     56800.     64000

  FACE AREA=       0.        17.        51.       120.       221.       314.       412.       504.       624.       751.
                 904.      1212.

   CAPACITY=       0.        57.       381.      1212.      2892.      5553.      9172.     13744.     19374.     26239.
               34502.     45045.

  ELEVATION=    1170.      1180.      1190.      1200.      1210.      1220.      1230.      1240.      1250.      1260.
                1270.      1280.

                          CREL   SPWID    COQW    EXPW   ELEVL    COQL   CAREA    EXPL
                        1260.0    -0.0    -0.0    -0.0    -0.0    -0.0    -0.0    -0.0

                                                  DAM DATA
                                        TOPEL    COQD    EXPD  DAMWID
                                       1272.0     2.8     1.5   2000.
```

STATION DAM, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

MO.DA	HR.MN	PERIOD	HOURS	INFLOW	OUTFLOW	STORAGE	STAGE
1.01	.10	1	.17	91.	825.	26606.	1260.5
1.01	.20	2	.33	116.	798.	26596.	1260.5
1.01	.30	3	.50	143.	772.	26587.	1260.5
1.01	.40	4	.67	160.	749.	26579.	1260.5
1.01	.50	5	.83	168.	727.	26571.	1260.4
1.01	1.00	6	1.00	172.	706.	26563.	1260.4
1.01	1.10	7	1.17	173.	685.	26556.	1260.4
1.01	1.20	8	1.33	173.	666.	26549.	1260.4
1.01	1.30	9	1.50	172.	647.	26543.	1260.4
1.01	1.40	10	1.67	172.	629.	26536.	1260.4
1.01	1.50	11	1.83	171.	612.	26530.	1260.4
1.01	2.00	12	2.00	172.	595.	26524.	1260.4
1.01	2.10	13	2.17	176.	579.	26518.	1260.4
1.01	2.20	14	2.33	184.	564.	26513.	1260.4
1.01	2.30	15	2.50	195.	550.	26508.	1260.4
1.01	2.40	16	2.67	211.	537.	26503.	1260.4
1.01	2.50	17	2.83	229.	524.	26499.	1260.3
1.01	3.00	18	3.00	251.	514.	26495.	1260.3
1.01	3.10	19	3.17	275.	504.	26492.	1260.3
1.01	3.20	20	3.33	301.	496.	26489.	1260.3
1.01	3.30	21	3.50	329.	489.	26486.	1260.3
1.01	3.40	22	3.67	360.	484.	26484.	1260.3
1.01	3.50	23	3.83	392.	479.	26483.	1260.3
1.01	4.00	24	4.00	425.	477.	26482.	1260.3
1.01	4.10	25	4.17	459.	475.	26481.	1260.3
1.01	4.20	26	4.33	494.	475.	26481.	1260.3
1.01	4.30	27	4.50	528.	477.	26482.	1260.3
1.01	4.40	28	4.67	563.	479.	26483.	1260.3
1.01	4.50	29	4.83	598.	483.	26484.	1260.3
1.01	5.00	30	5.00	632.	488.	26486.	1260.3
1.01	5.10	31	5.17	665.	494.	26488.	1260.3
1.01	5.20	32	5.33	698.	501.	26491.	1260.3
1.01	5.30	33	5.50	730.	509.	26494.	1260.3
1.01	5.40	34	5.67	761.	518.	26497.	1260.3
1.01	5.50	35	5.83	791.	528.	26500.	1260.3
1.01	6.00	36	6.00	820.	539.	26504.	1260.4
1.01	6.10	37	6.17	952.	552.	26509.	1260.4
1.01	6.20	38	6.33	1305.	574.	26516.	1260.4
1.01	6.30	39	6.50	1764.	610.	26529.	1260.4
1.01	6.40	40	6.67	2206.	662.	26548.	1260.4
1.01	6.50	41	6.83	2609.	729.	26572.	1260.4
1.01	7.00	42	7.00	3001.	807.	26600.	1260.5
1.01	7.10	43	7.17	3383.	918.	26632.	1260.5
1.01	7.20	44	7.33	3759.	1064.	26667.	1260.6
1.01	7.30	45	7.50	4133.	1222.	26706.	1260.6
1.01	7.40	46	7.67	4503.	1393.	26747.	1260.7
1.01	7.50	47	7.83	4864.	1573.	26791.	1260.7
1.01	8.00	48	8.00	5214.	1763.	26838.	1260.8
1.01	8.10	49	8.17	5546.	1962.	26886.	1260.9
1.01	8.20	50	8.33	5859.	2166.	26936.	1260.9
1.01	8.30	51	8.50	6148.	2376.	26988.	1261.0
1.01	8.40	52	8.67	6412.	2639.	27040.	1261.1
1.01	8.50	53	8.83	6652.	2912.	27091.	1261.1
1.01	9.00	54	9.00	6868.	3181.	27143.	1261.2
1.01	9.10	55	9.17	7062.	3446.	27193.	1261.3
1.01	9.20	56	9.33	7239.	3704.	27242.	1261.3
1.01	9.30	57	9.50	7398.	3956.	27290.	1261.4
1.01	9.40	58	9.67	7543.	4201.	27337.	1261.4
1.01	9.50	59	9.83	7674.	4438.	27382.	1261.5
1.01	10.00	60	10.00	7794.	4708.	27426.	1261.6
1.01	10.10	61	10.17	7902.	4964.	27467.	1261.6
1.01	10.20	62	10.33	8001.	5208.	27507.	1261.7
1.01	10.30	63	10.50	8090.	5439.	27544.	1261.7
1.01	10.40	64	10.67	8171.	5658.	27580.	1261.8
1.01	10.50	65	10.83	8245.	5866.	27613.	1261.8
1.01	11.00	66	11.00	8313.	6062.	27645.	1261.8
1.01	11.10	67	11.17	8374.	6248.	27675.	1261.9
1.01	11.20	68	11.33	8430.	6423.	27704.	1261.9
1.01	11.30	69	11.50	8482.	6588.	27731.	1261.9
1.01	11.40	70	11.67	8529.	6743.	27756.	1262.0
1.01	11.50	71	11.83	8572.	6900.	27780.	1262.0
1.01	12.00	72	12.00	8611.	7063.	27802.	1262.0

1.01	12.10	73	12.17	9140.	7237.	27826.	1262.1
1.01	12.20	74	12.33	10702.	7494.	27861.	1262.1
1.01	12.30	75	12.50	12729.	7899.	27916.	1262.2
1.01	12.40	76	12.67	14637.	8452.	27992.	1262.3
1.01	12.50	77	12.83	16314.	9123.	28084.	1262.4
1.01	13.00	78	13.00	17896.	9883.	28189.	1262.5
1.01	13.10	79	13.17	19525.	10722.	28305.	1262.7
1.01	13.20	80	13.33	21370.	11643.	28432.	1262.8
1.01	13.30	81	13.50	23303.	12672.	28573.	1263.0
1.01	13.40	82	13.67	25161.	13949.	28723.	1263.2
1.01	13.50	83	13.83	26888.	15279.	28880.	1263.4
1.01	14.00	84	14.00	28512.	16642.	29042.	1263.6
1.01	14.10	85	14.17	30217.	18034.	29207.	1263.8
1.01	14.20	86	14.33	32232.	19479.	29379.	1264.0
1.01	14.30	87	14.50	34313.	21062.	29558.	1264.2
1.01	14.40	88	14.67	36215.	22685.	29743.	1264.5
1.01	14.50	89	14.83	37892.	24321.	29929.	1264.7
1.01	15.00	90	15.00	39407.	25945.	30116.	1264.9
1.01	15.10	91	15.17	40683.	27305.	30300.	1265.1
1.01	15.20	92	15.33	42274.	28543.	30487.	1265.4
1.01	15.30	93	15.50	46256.	29910.	30694.	1265.6
1.01	15.40	94	15.67	57657.	31817.	30985.	1266.0
1.01	15.50	95	15.83	73947.	34012.	31438.	1266.5
1.01	16.00	96	16.00	82171.	36948.	32024.	1267.2
1.01	16.10	97	16.17	81862.	40399.	32621.	1267.9
1.01	16.20	98	16.33	78978.	42958.	33155.	1268.5
1.01	16.30	99	16.50	77157.	45064.	33624.	1269.0
1.01	16.40	100	16.67	75664.	46576.	34045.	1269.5
1.01	16.50	101	16.83	74547.	47940.	34429.	1269.9
1.01	17.00	102	17.00	73783.	49717.	34778.	1270.3
1.01	17.10	103	17.17	72722.	51420.	35090.	1270.6
1.01	17.20	104	17.33	70847.	52879.	35361.	1270.9
1.01	17.30	105	17.50	68485.	53834.	35585.	1271.2
1.01	17.40	106	17.67	65814.	54518.	35764.	1271.4
1.01	17.50	107	17.83	63063.	55025.	35897.	1271.5
1.01	18.00	108	18.00	60182.	55361.	35986.	1271.6
1.01	18.10	109	18.17	56647.	55516.	36026.	1271.6
1.01	18.20	110	18.33	51803.	55450.	36009.	1271.6
1.01	18.30	111	18.50	46601.	55133.	35925.	1271.5
1.01	18.40	112	18.67	42799.	54600.	35785.	1271.4
1.01	18.50	113	18.83	39125.	53900.	35602.	1271.2
1.01	19.00	114	19.00	35536.	52986.	35391.	1271.0
1.01	19.10	115	19.17	32414.	51625.	35128.	1270.7
1.01	19.20	116	19.33	29563.	50135.	34854.	1270.4
1.01	19.30	117	19.50	26760.	48534.	34563.	1270.1
1.01	19.40	118	19.67	24051.	47314.	34252.	1269.7
1.01	19.50	119	19.83	21486.	46136.	33922.	1269.4
1.01	20.00	120	20.00	19114.	44861.	33575.	1269.0
1.01	20.10	121	20.17	16958.	43240.	33217.	1268.6
1.01	20.20	122	20.33	15016.	41582.	32853.	1268.1
1.01	20.30	123	20.50	13307.	39637.	32489.	1267.7
1.01	20.40	124	20.67	11815.	37563.	32130.	1267.3
1.01	20.50	125	20.83	10531.	35619.	31780.	1266.9
1.01	21.00	126	21.00	9428.	34013.	31438.	1266.5
1.01	21.10	127	21.17	8528.	32434.	31104.	1266.1
1.01	21.20	128	21.33	7794.	30495.	30783.	1265.7
1.01	21.30	129	21.50	7145.	28494.	30480.	1265.4
1.01	21.40	130	21.67	6565.	26602.	30195.	1265.0
1.01	21.50	131	21.83	6071.	24334.	29931.	1264.7
1.01	22.00	132	22.00	5665.	22231.	29691.	1264.4
1.01	22.10	133	22.17	5285.	20313.	29473.	1264.1
1.01	22.20	134	22.33	4931.	18606.	29276.	1263.9
1.01	22.30	135	22.50	4601.	17095.	29096.	1263.7
1.01	22.40	136	22.67	4293.	15708.	28931.	1263.5
1.01	22.50	137	22.83	4034.	14439.	28781.	1263.3
1.01	23.00	138	23.00	3831.	13279.	28644.	1263.1
1.01	23.10	139	23.17	3641.	12272.	28520.	1263.0
1.01	23.20	140	23.33	3464.	11447.	28405.	1262.8
1.01	23.30	141	23.50	3298.	10683.	28299.	1262.7
1.01	23.40	142	23.67	3203.	9977.	28202.	1262.6
1.01	23.50	143	23.83	3134.	9328.	28113.	1262.4
1.02	0.00	144	24.00	3075.	8735.	28031.	1262.3

OUTFLOW IS 55516. AT TIME 18.17 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	55516.	45512.	16400.	16400.	2361582.
CMS	1572.	1289.	464.	464.	66873.
INCHES		21.07	30.37	30.37	30.37
MM		535.27	771.52	771.52	771.52
AC-FT		22568.	32529.	32529.	32529.
THOUS CU M		27837.	40124.	40124.	40124.

PLATE A-1
Sheet 9 of 10

MAXIMUM STORAGE = 36026.

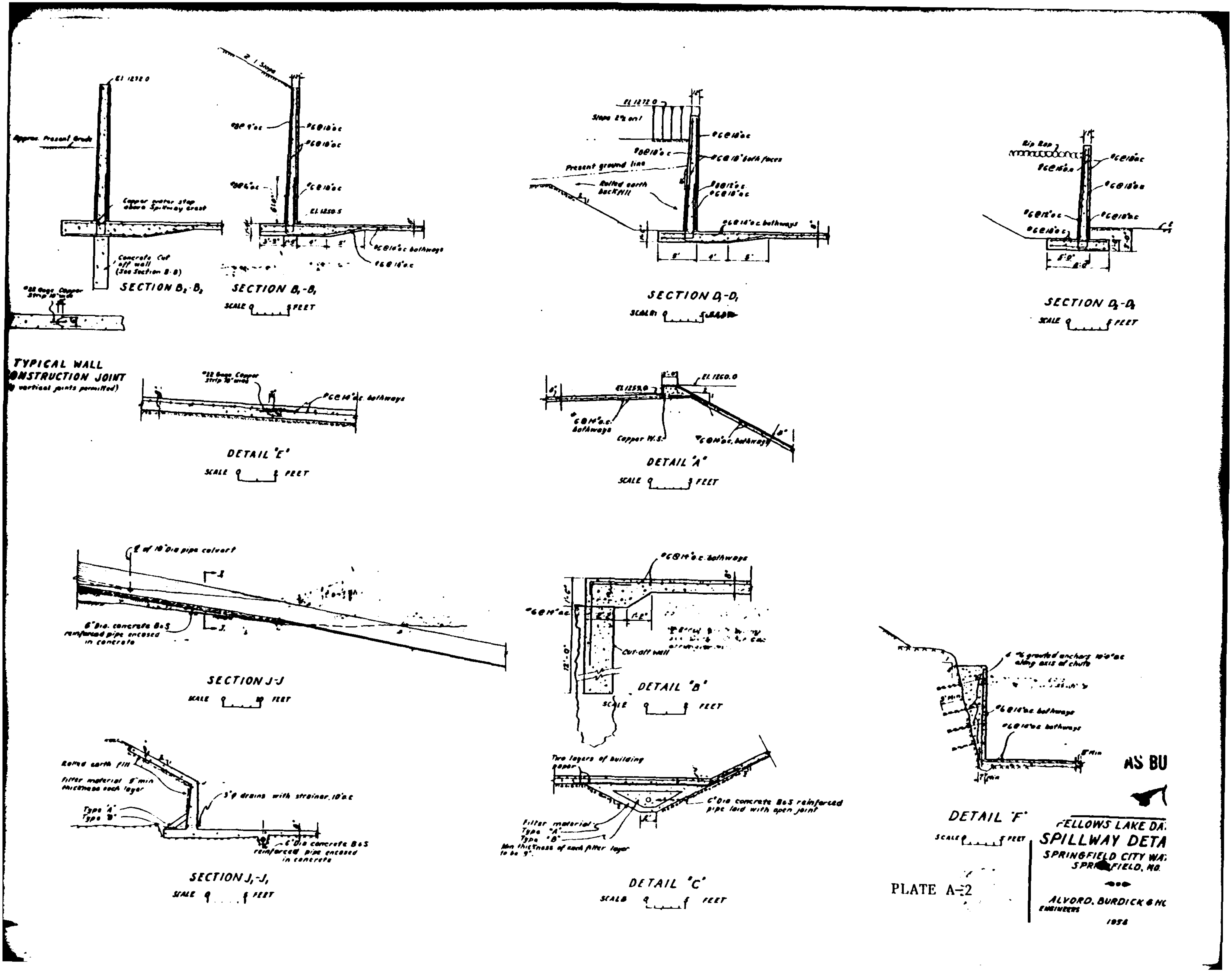
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1260.50	1260.00	1272.00
STORAGE	26616.	26239.	36368.
OUTFLOW	854.	0.	54857.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.40	1264.83	0.00	30035.	25244.	0.00	17.83	0.00
.50	1265.81	0.00	30851.	30940.	0.00	17.83	0.00
.90	1270.48	0.00	34942.	50612.	0.00	18.17	0.00
1.00	1271.64	0.00	36026.	55516.	0.00	18.17	0.00

PLATE A-1
Sheet 10 of 10


SECTION B2-B2
SECTION B1-B1
SECTION D1-D1
SECTION D2-D2
TYPICAL WALL CONSTRUCTION JOINT
DETAIL "E"
DETAIL "A"
SECTION J-J
DETAIL "B"
DETAIL "F"
SECTION J1-J1
DETAIL "C"
Cut-off wall
Two layers of building paper
Filter material
Type "A"
Type "B"
Rolled earth fill
Rip Rap
Present ground line
Rolled earth backfill
AS BU
FELLOWS LAKE DA
SPILLWAY DETA
SPRINGFIELD CITY WA
SPRINGFIELD, MO.
ALVORD, BURDICK & HO
ENGINEERS
1954
PLATE A-2

319

ENGINEERING GEOLOGIC REPORT ON FELLOWS LAKE SITE

GREENE COUNTY, MISSOURI

LOCATION: North central portion of Sec. 22, T. 30 N., R. 21 W., Bassville Quadrangle.

On February 23, 1977, a geological inspection was made on the Fellows Lake site at the request of the city of Springfield. A small hole has been discovered on top of the dam by one of the municipal workers and also two of the piezometer holes had indicated a raise in water level in the downstream slope of the dam.

Accompanying me on the investigation were two gentlemen from Harza Company, Chicago, IL and three officials from the city of Springfield. The hole which the city was worried about was located on top of the dam near the south abutment. The hole was approximately 8 inches in diameter and 18 inches deep. It had straight sides and consisted of brown soil mixed with what appeared to be either limestone dust, grout, or possibly bentonite. The hole was situated in a line where grout holes had been drilled in the 1950's when this dam was constructed. The Harza people shoved a reinforcing rod down the hole for depth of about 5 feet. The soil was soft inside this hole. However, on each side of the hole, the rod encountered hard soil. The consensus of opinion was that this hole was probably an old grout hole that had been filled with soil and soil within the hole had settled. The hole was not a result of piping caused by water movement through the dam.

The piezometer holes that had indicated a rise in water were checked to be sure they were not plugged. A tape with a steel U-bolt was placed on the end of the tape and run down the hole. Holes measured from 10 to 11 feet deep. The piezometer holes that indicated high water were close to gether. One of the holes had a water depth of 1 foot below the surface of the dam. A careful check was made on the slopes of the dam downslope from the piezometer holes. In places there was wet soil but this was from thawing snow and ice. There were no signs of slippage or any indication of wet saturated soil on the slopes of the dam below the piezometer holes.

No reason could be determined for the high water tables in the piezometers. It was the opinion that the high water readings were of local significance only and that they were not an indication of widespread raise in phreatic water level in the dam. It was suggested that the city continue measurements in the piezometer holes.

SUMMARY:

The hole in top of the dam was caused by settlement of soil in an old grout hole. The high water readings in the piezometer holes were of local influence and there was no surface indication of soil slipping on the dam slopes.

John W. Whitfield, Geologist
Applied Engineering & Urban Geology
Geology & Land Survey
March 1, 1977

APPENDIX B

ENGINEERING GEOLOGIC REPORT ON THE FELLOWS LAKE SITE

Greene County

LOCATION: Portions of Sec. 22, 23, 24 and 25, T. 30 N., R. 21 W.,

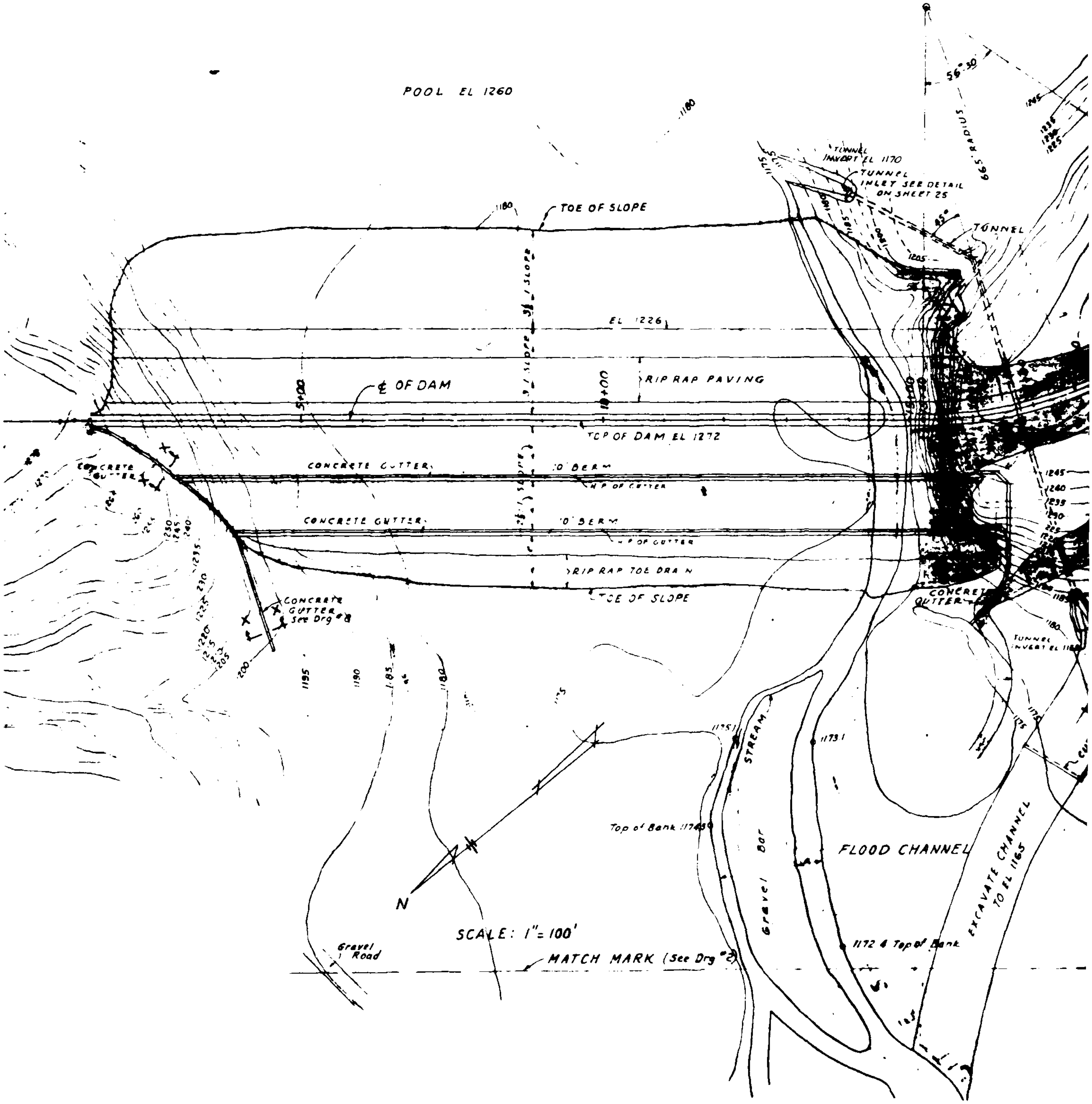
Several bedrock formations occur in the Sac River Valley and adjoining watershed slopes in and near Fellows Lake. Bedrock in the valley is made up of the Northview Formation, a massively bedded siltstone and shale. This bedrock formation is relatively impermeable and stable except for areas where the shale portion has been severly weathered. Bedrock on the valley slopes is made up of a very cherty limestone. This formation, the Elsey, weathers to a rubbley soil made up of more than 50 percent angular chert fragments. The intermixed fine material consists of silt and silty clay. Thus this very stony soil can be a source for suitable fill material in a dam provided construction procedures are adequate. Limited portions of the upper watershed slopes are underlain by the Burlington Limestone. This is a massively bedded limestone with some chert present. The soil derived from weathering of the Burlington Limestone is a moderately to highly permeable red clay with a minor amount of admixed stones. The setting of Fellows Lake is representative of gaining river valleys and larger streams in southwestern Missouri. It is not typical of small tributary valleys that are present in the karst or sinkhole setting that is widespread in this region. The variation of rock formations is somewhat unusual however even for the larger valleys. Many lakes in this setting are underlain by only one formation, usually the Burlington Limestone. Typically, the soils in the watershed are those that have been derived by weathering of the Burlington Limestone. Consequently the stone content is somewhat less than that which characterizes the watershed of Fellows Lake. However, the soils and bedrock within Fellows Lake as within much of southwestern Missouri are moderately to highly permeable. Consequently considerable storage of moisture during rainfall occurs. Thus sustained flow can be expected in those streams recharged by springs from the moisture storage within the permeable soil and moderately to highly permeable bedrock.

The soil is not susceptible to erosion problems unless crop/and/or development procedures are extremely lax. Again this is typical of the general region.

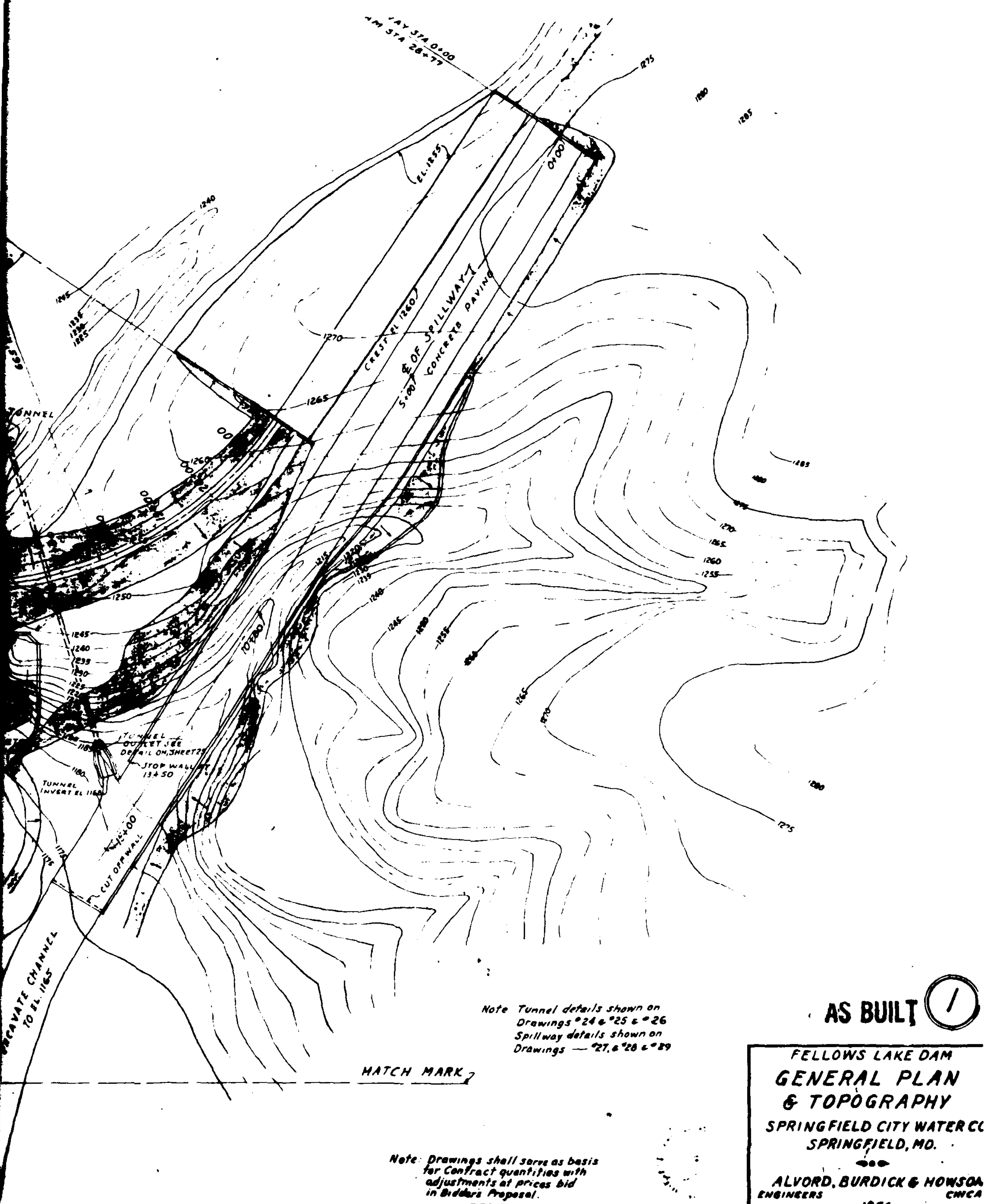
J. Hadley Williams, Chief
Applied Engineering & Urban Geology Section
Office of State Geologist
January 10, 1975

cpy: Jim Barks
U.S.G.S. Water Resources Division
Rolla, Missouri 65401

APPENDIX B

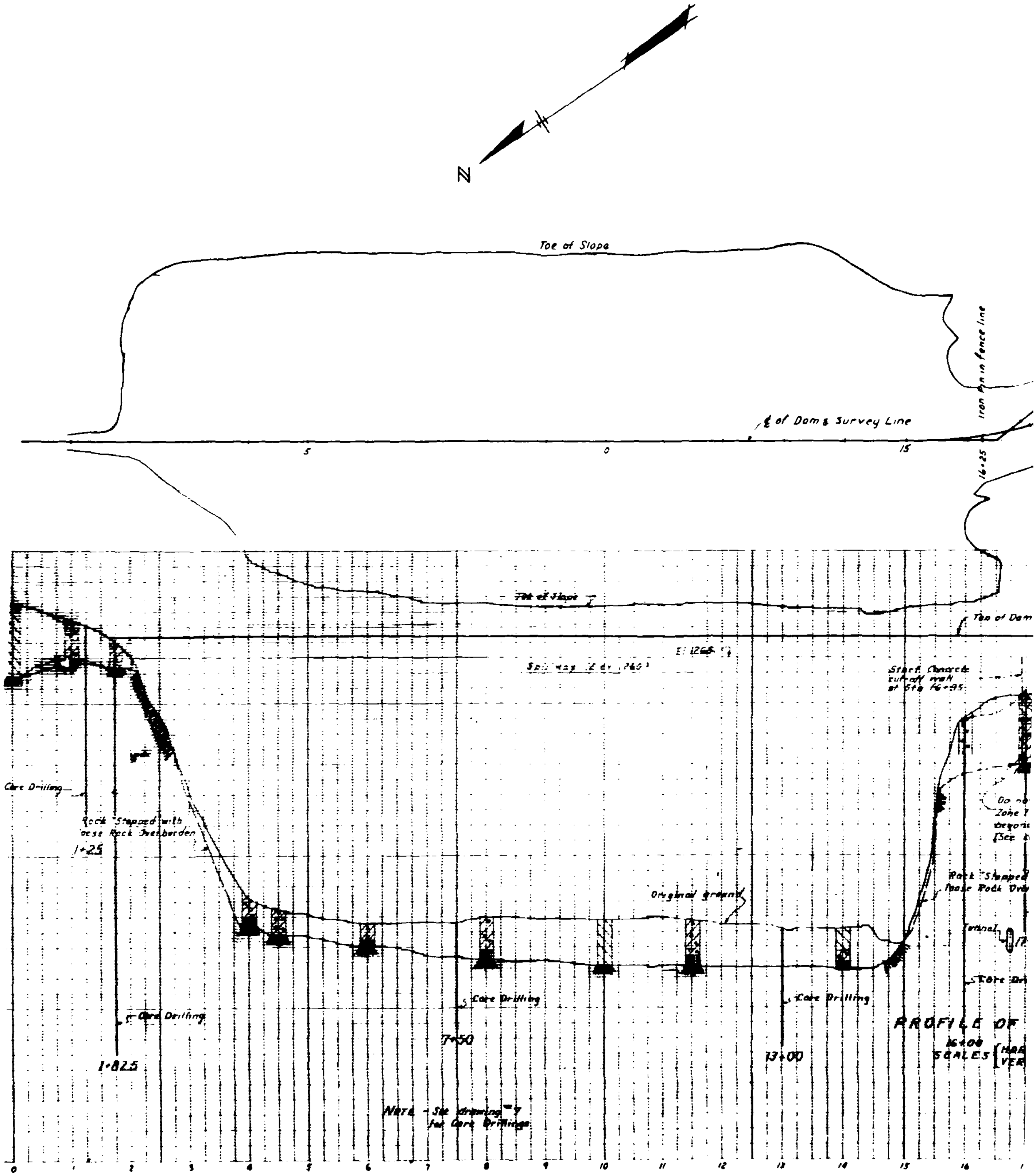


POOL EL 1260
TOE OF SLOPE
TUNNEL INVERT EL 1170
TUNNEL INLET SEE DETAIL ON SHEET 25
TUNNEL
665' RADIUS
56°30'
EL 1226
RIP RAP PAVING
℄ OF DAM
5+00
10+00
TOP OF DAM EL 1272
CONCRETE GUTTER
10' BERM
CONCRETE GUTTER
10' BERM
RIP RAP TOE DRAIN
TOE OF SLOPE
CONCRETE GUTTER
CONCRETE GUTTER See Drg #8
CONCRETE GUTTER
STREAM
Top of Bank 1174
Gravel Bar
FLOOD CHANNEL
EXCAVATE CHANNEL TO EL 1165
1172 & Top of Bank
N
SCALE: 1"= 100'
Gravel Road
MATCH MARK (See Drg #2)

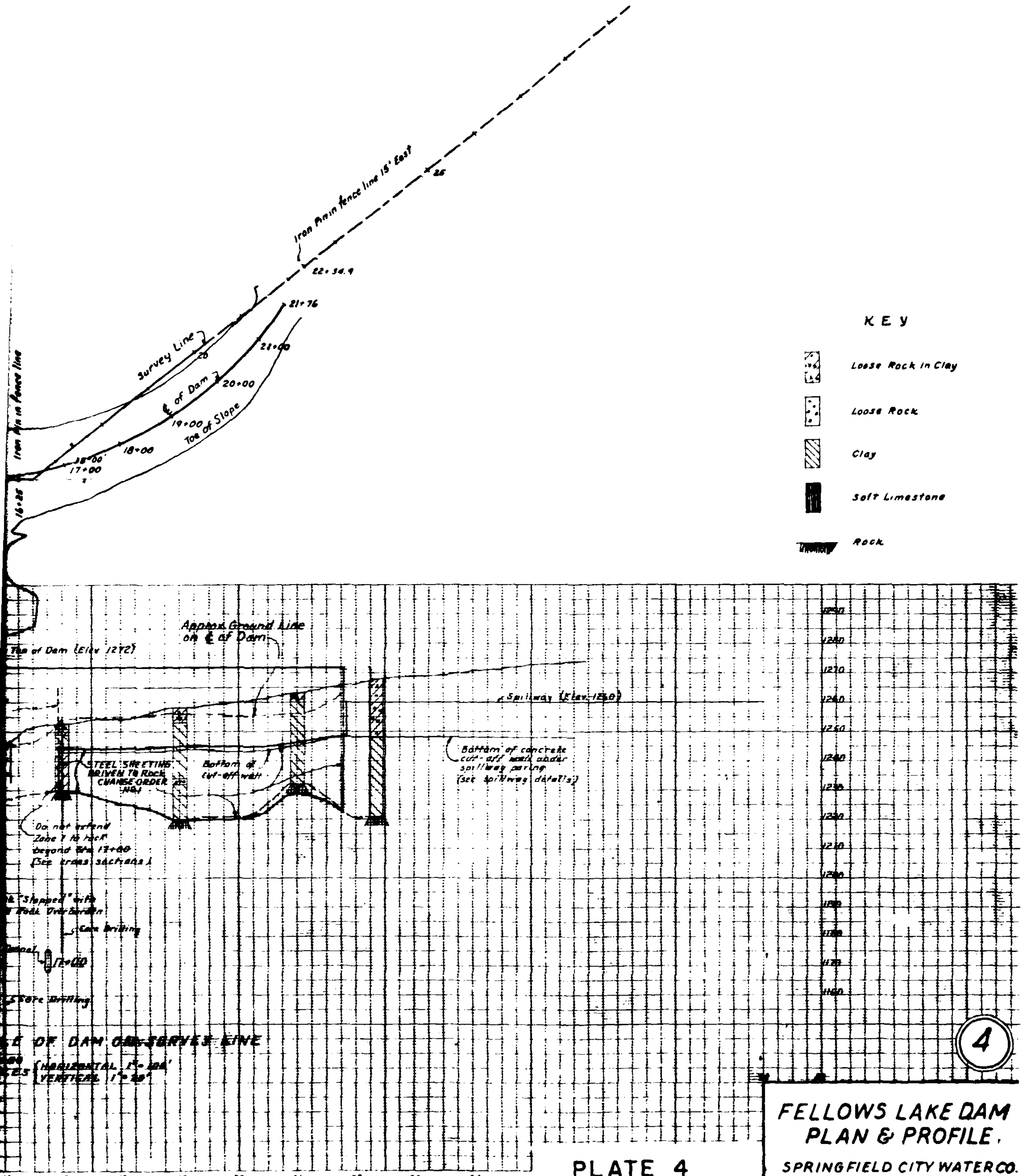


PREPARED BY REITZ & JENS, INC.
FOR A PHASE I DAM INSPECTION

PLATE 3



N
Toe of Slope
℄ of Dam & Survey Line
Iron Pin in Fence line
5
15
16+25
Toe of Slope
Toe of Dam
Start Concrete cut-off wall at Sta 16+95
Core Drilling
Rock Stripped with loose Rock Overburden
1+25
Core Drilling
1+825
Original Ground
Core Drilling
7+50
Core Drilling
13+00
Rock Stripped
Loose Rock Ovb
Tunnel
PROFILE OF
16+00
SCALES
Note - See drawing #7 for Core Drillings
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16



KEY

- Loose Rock in Clay
- Loose Rock
- Clay
- Soft Limestone
- Rock

PLATE 4

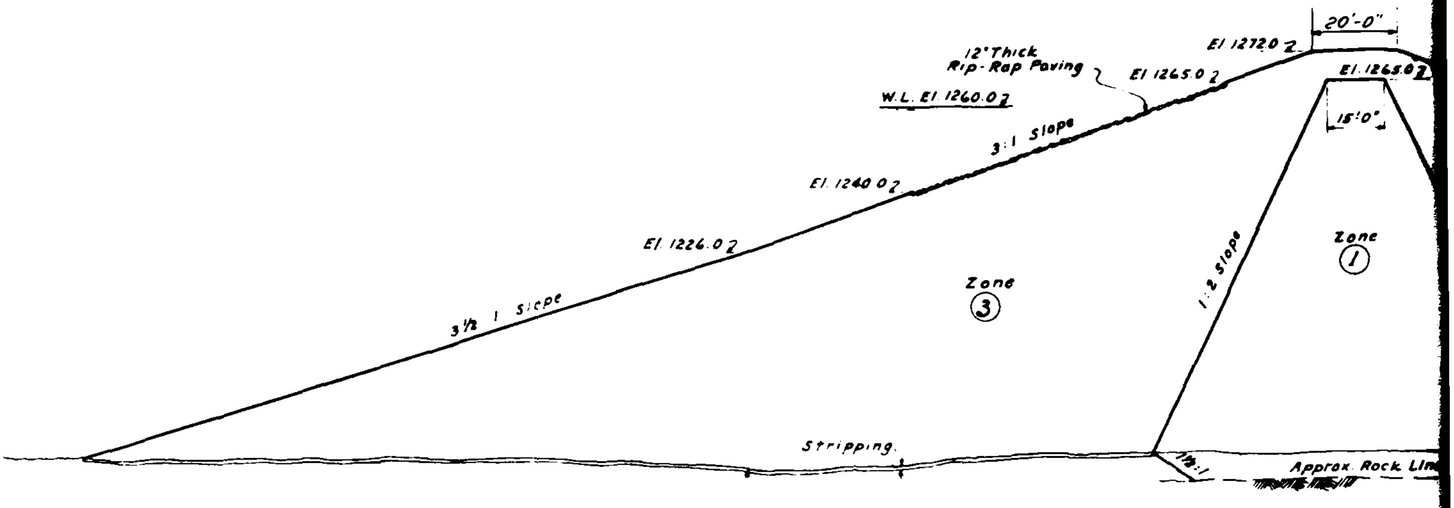
PREPARED BY REITZ & JENS, INC.
FOR A PHASE I DAM INSPECTION

FELLOWS LAKE DAM
PLAN & PROFILE.

SPRINGFIELD CITY WATER CO.
SPRINGFIELD, MO.

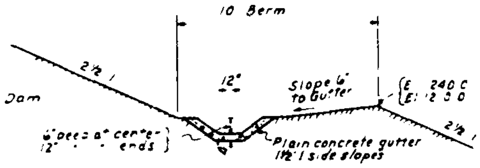
AS BUILT

ALVORD, BURDICK & HOWSON
ENGINEERS CHICAGO



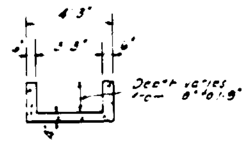
TYPICAL SECTION

Scale 1" =

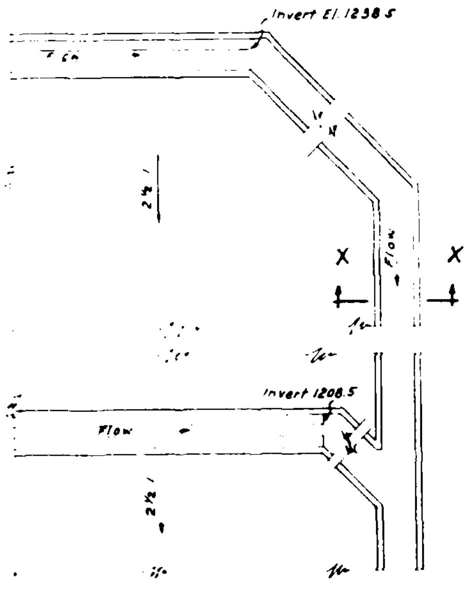


DETAIL of BERM GUTTER DRAINS

Scale ¼" = 1'0"

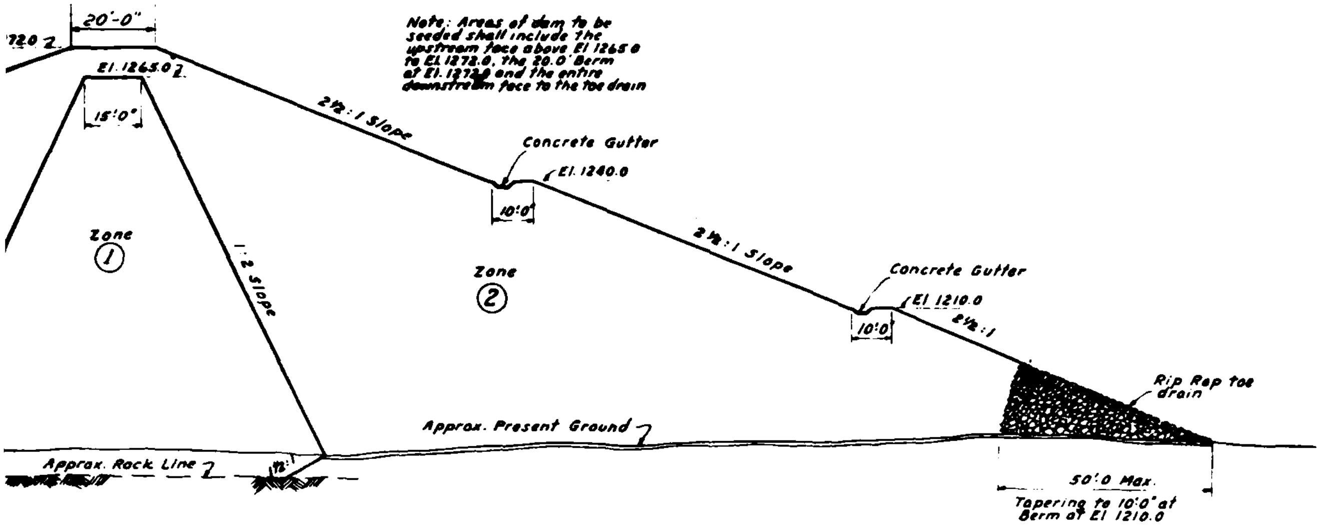


SECTION X-X



GUTTER at END of BERMS

Scale ⅛" = 1'0"



L SECTION THRU DAM

Scale 1" = 20'

varies
... to 1.9'

8

FELLOWS LAKE DAM

TYPICAL DETAILS

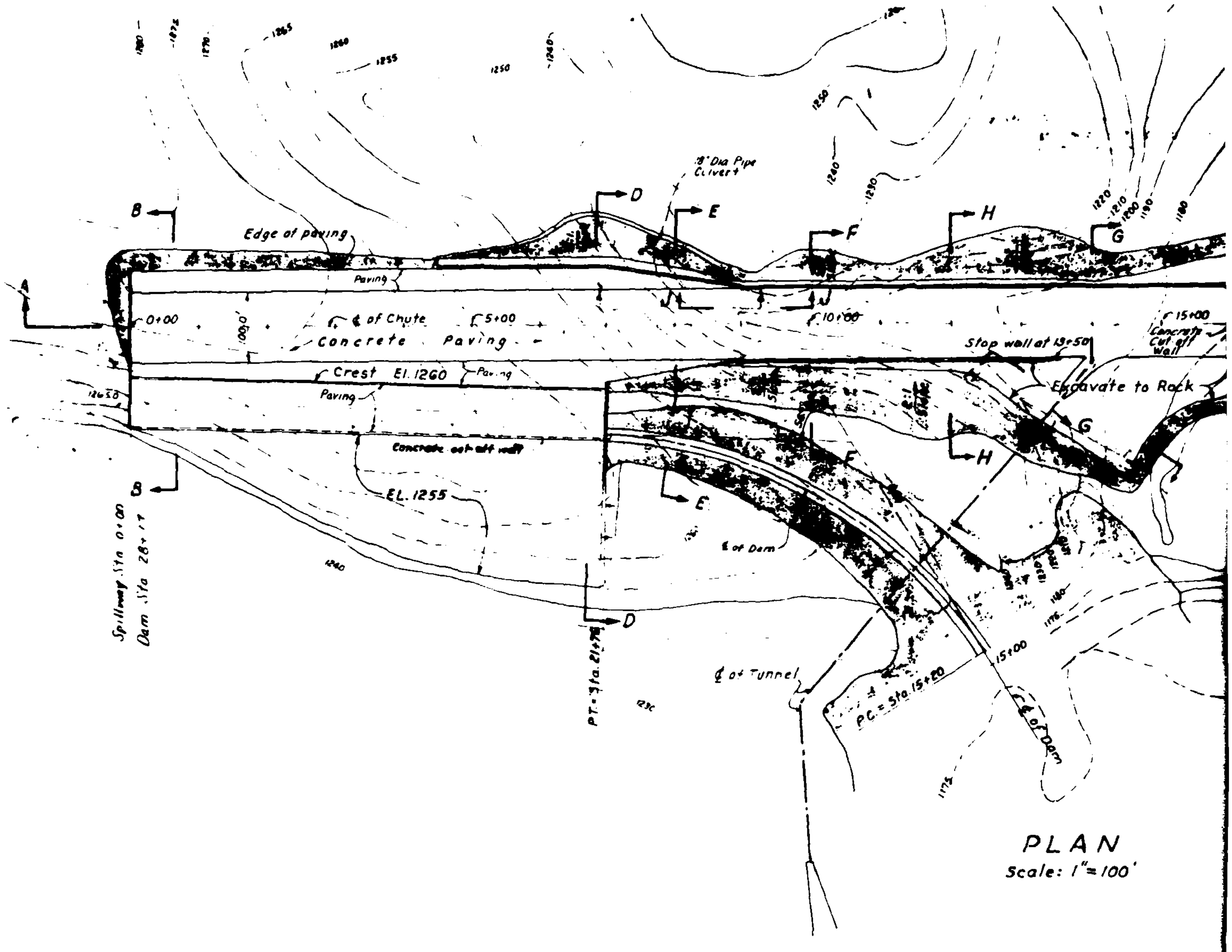
SPRINGFIELD CITY WATER CO

SPRINGFIELD, MO.

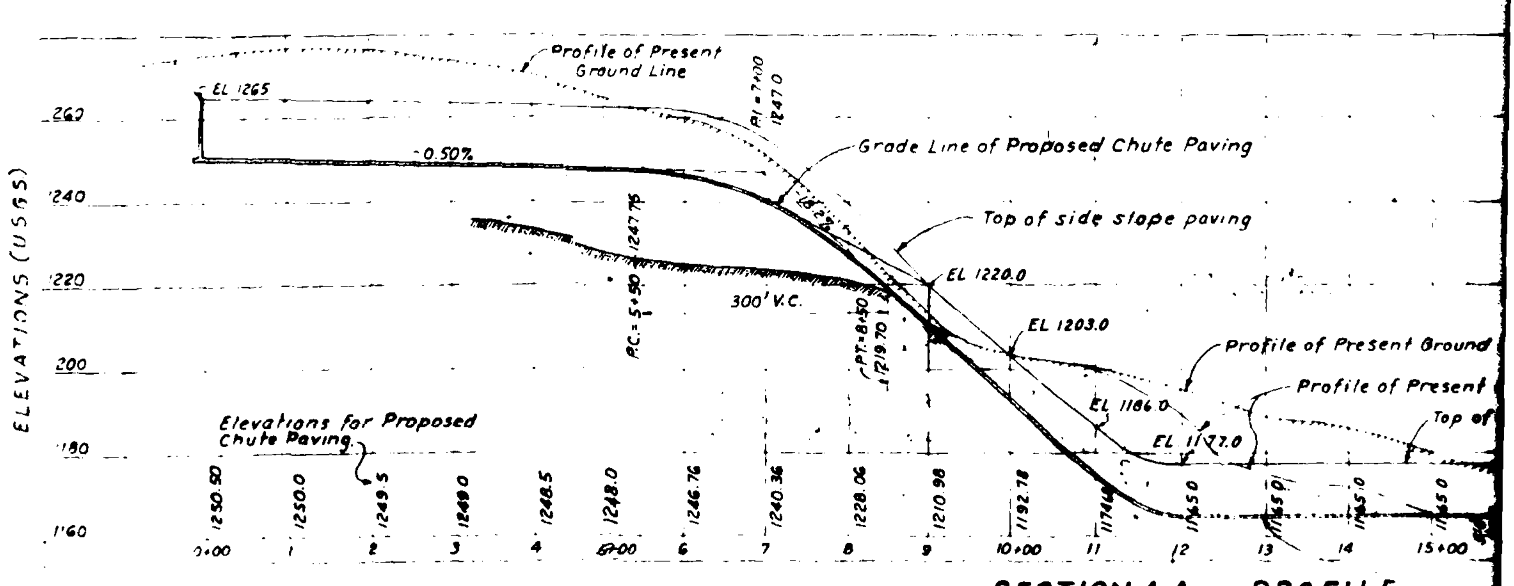
AS BUILT

PREPARED BY REITZ & JENS, INC.
FOR A PHASE I DAM INSPECTION

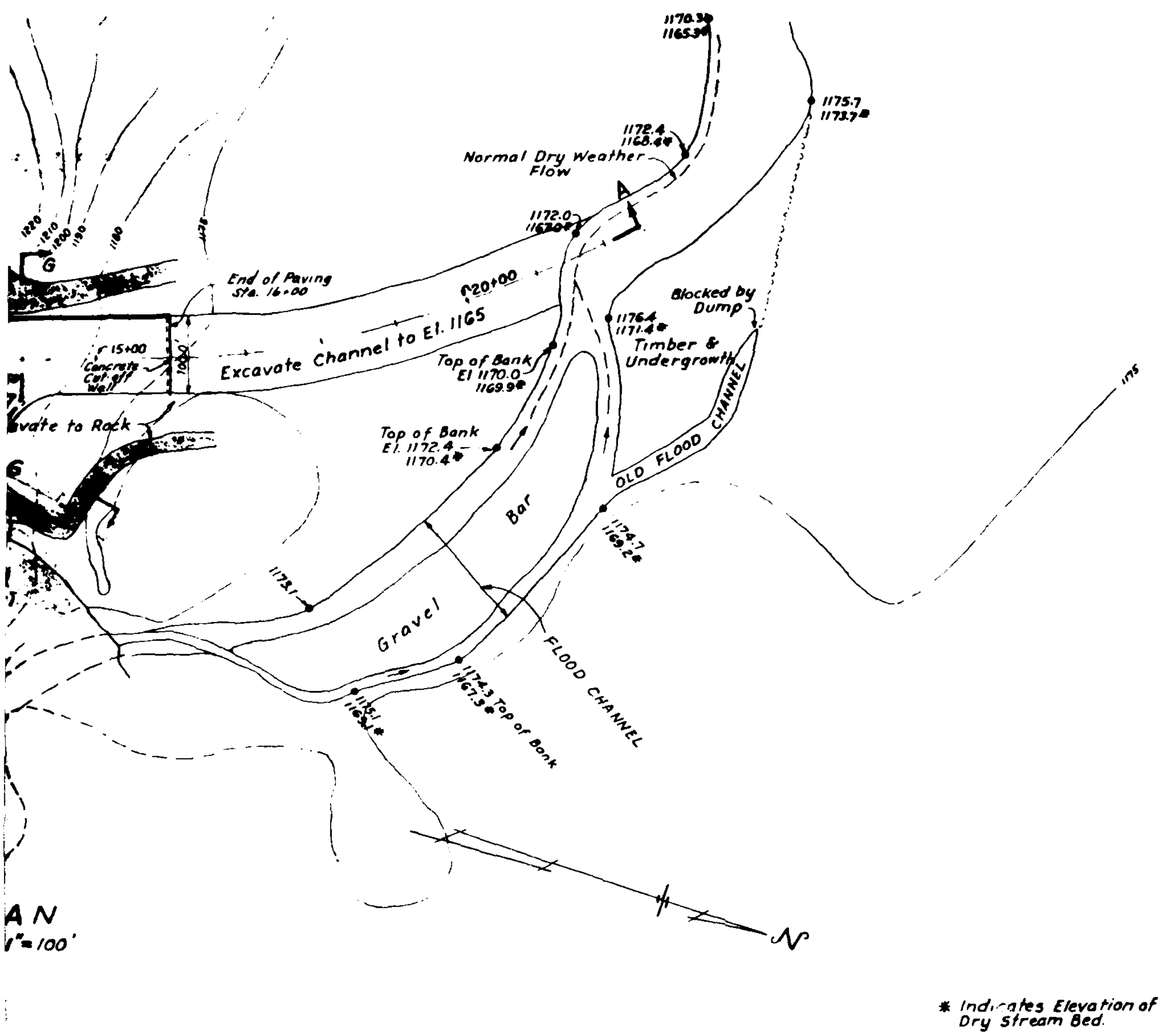
PLATE 5

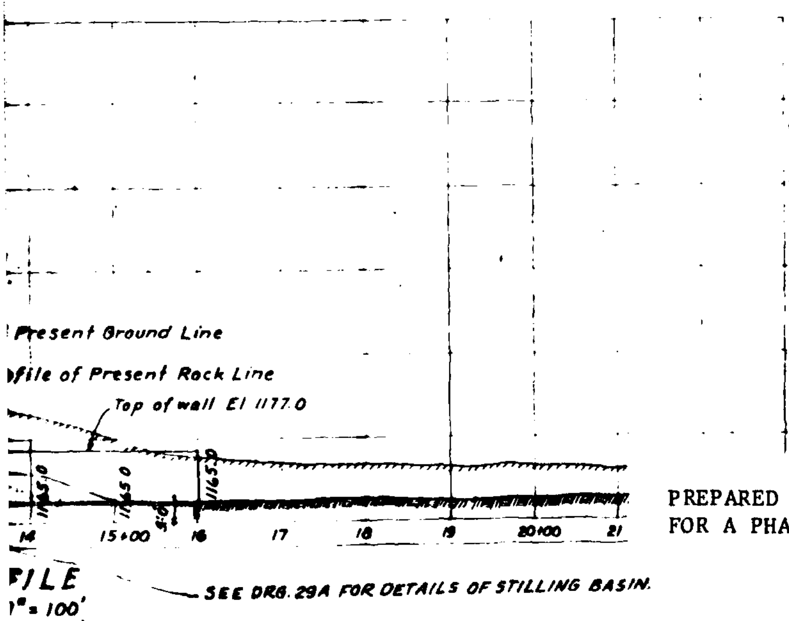


PLAN
Scale: 1" = 100'



SECTION A-A — PROFILE
SCALES: {HORIZ. 1" = 100'





THE LOWERED FLOWLINE AROUND STATION 13 TO INDUCE A HYDRAULIC JUMP WITHIN THE CONCRETE LINED SECTION OF THE CHUTE IS NOT INDICATED.

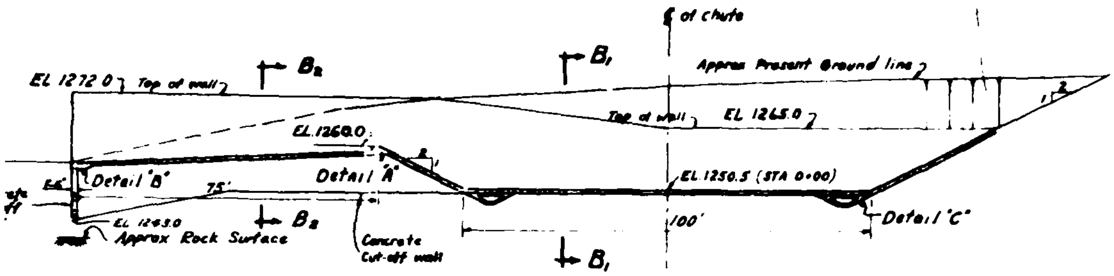
NOTE: Tunnel details shown on Drawings #24, 25, & 26.

AS BUILT 27

PREPARED BY REITZ & JENS, INC.
FOR A PHASE I DAM INSPECTION

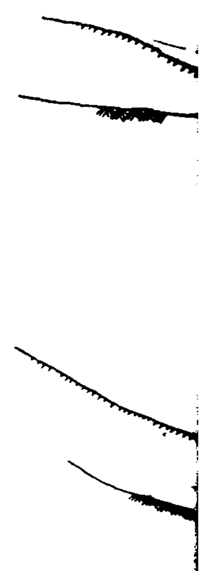
PLATE 6

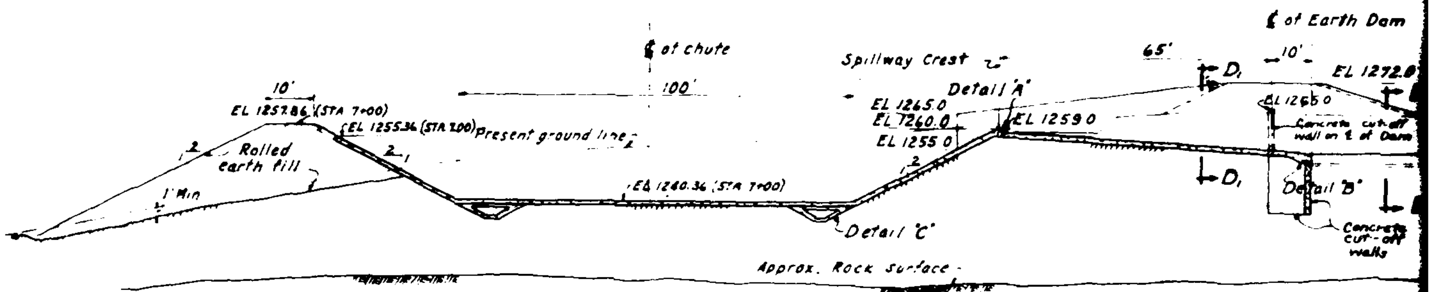
FELLOWS LAKE DAM
SPILLWAY
SPRINGFIELD CITY WATER CO.
SPRINGFIELD, MO.



SECTION B-B

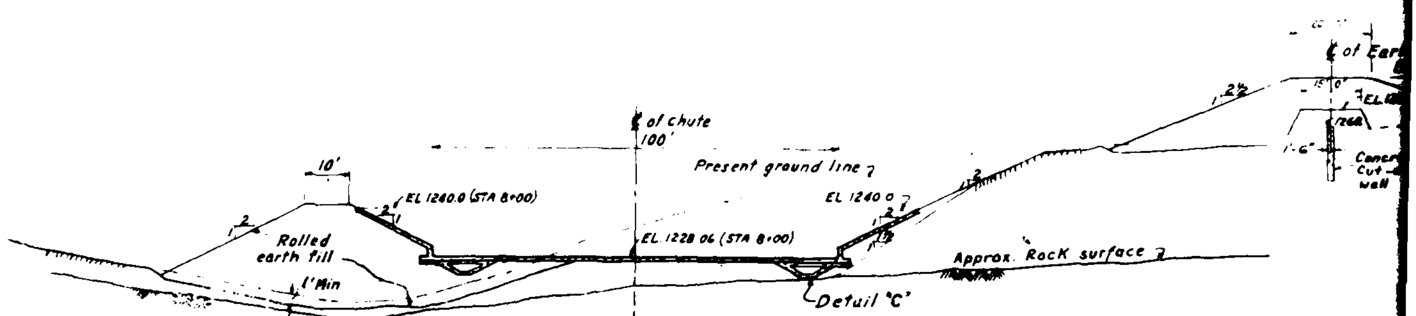
Scale 0 20 Feet





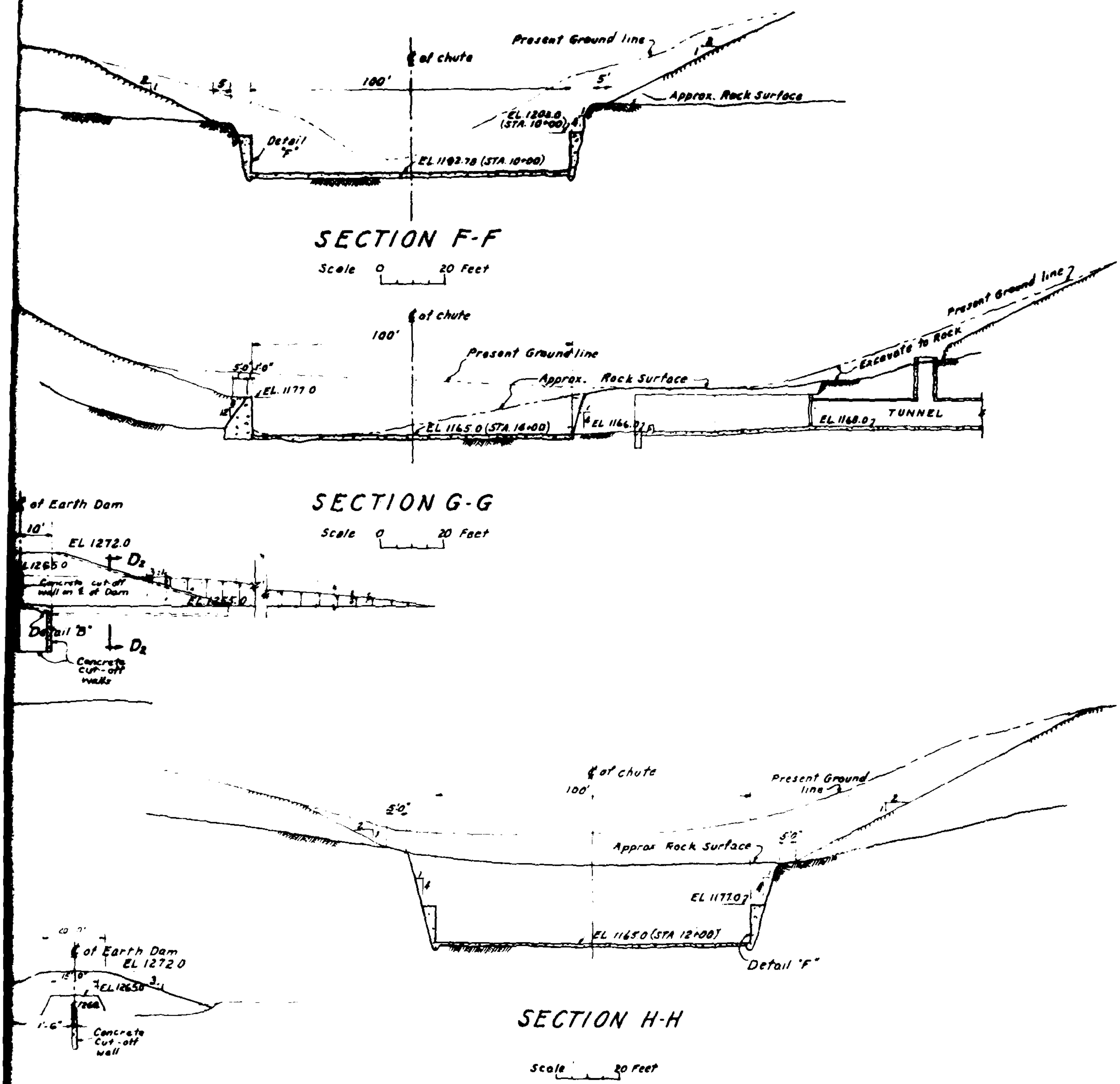
SECTION D-D

Scale 0 20 Feet



SECTION E-E

Scale 0 20 Feet



AS BUILT

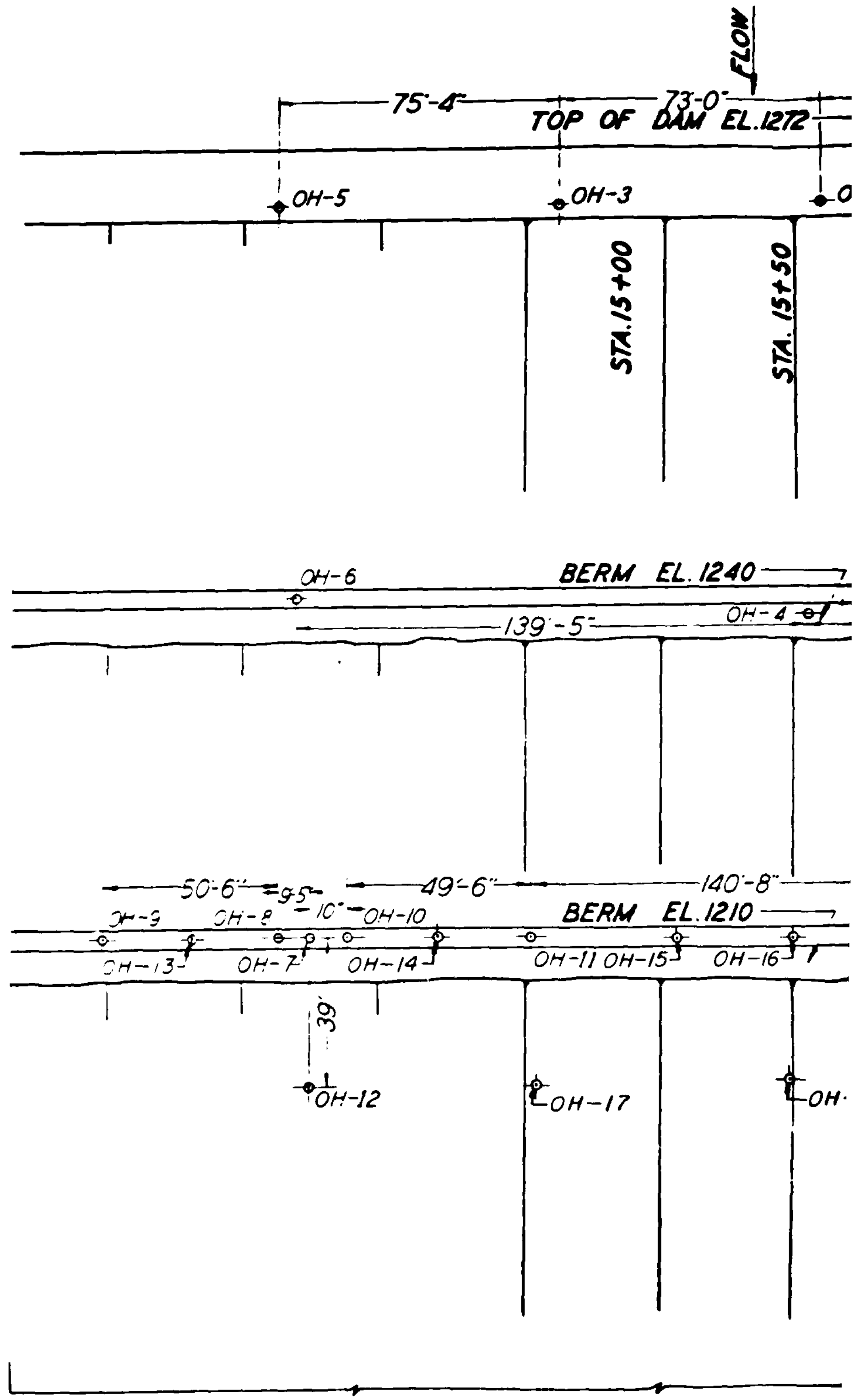
28

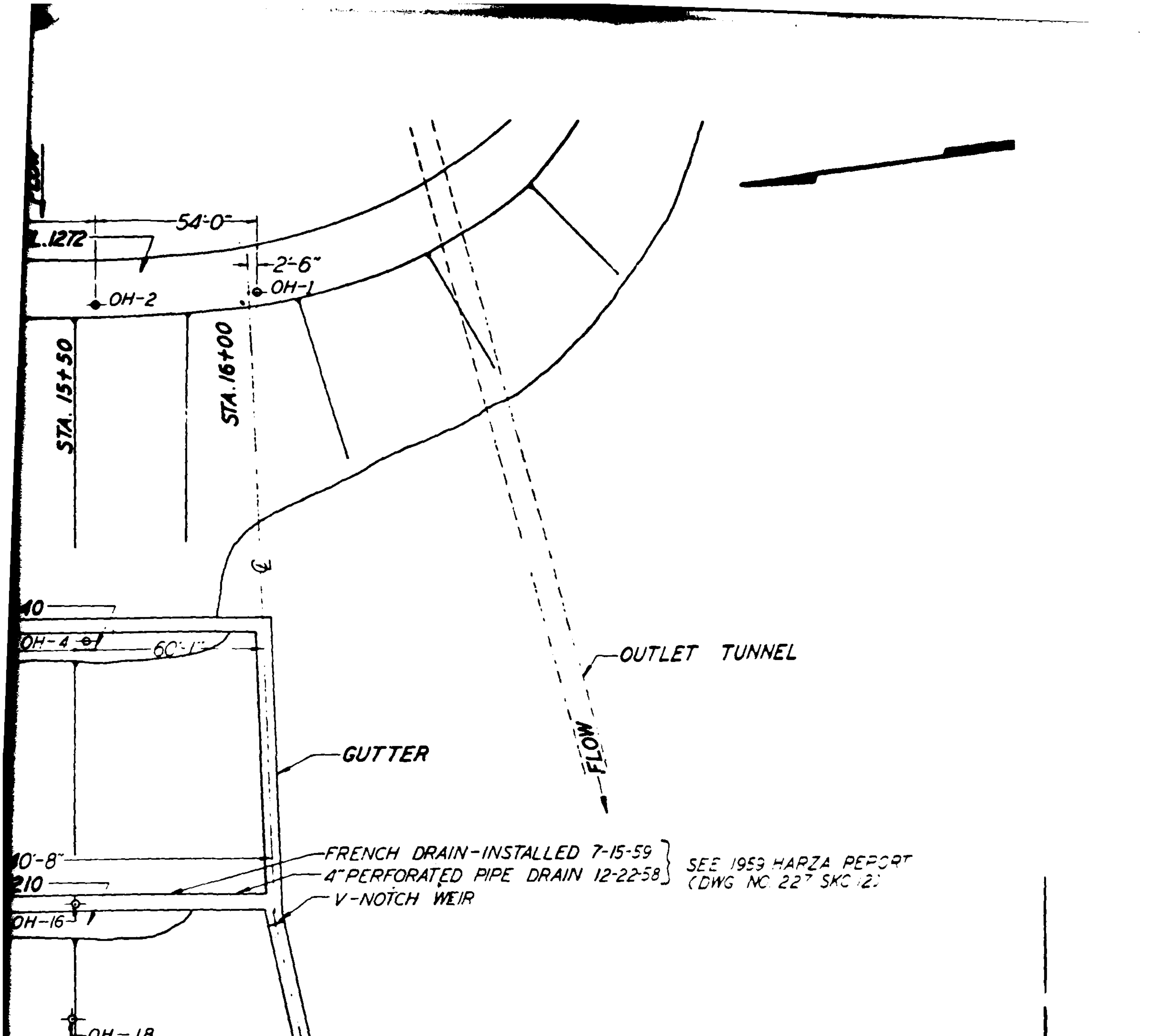
FELLOWS LAKE DAM
SPILLWAY DETAILS
SPRINGFIELD CITY WATER CO.
SPRINGFIELD, MO.

ALVORD, BURDICK & HOWSON

PREPARED BY REITZ & JENS, INC.
FOR A PHASE I DAM INSPECTION

PLATE 7


FLOW
75'-4"
73'-0"
TOP OF DAM EL. 1272
OH-5
OH-3
STA. 15+00
STA. 15+50
OH-6
BERM EL. 1240
OH-4
139'-5"
50'-6"
9'-5"
10"
49'-6"
140'-8"
OH-9
OH-8
OH-10
BERM EL. 1210
OH-13
OH-7
OH-14
OH-11
OH-15
OH-16
39'
OH-12
OH-17



REITZ & JENS, INÇ. USES THE TERMINOLOGY "PIEZOMETER"
IN LIEU OF "OBSERVATION HOLES"

SPILLWAY ELEVATION 1260

CITY UTILITIES OF SPRINGFIELD, MO.

J.O.
AUTH:
FOREMAN:
DATE ISSUED:
DATE COMP:

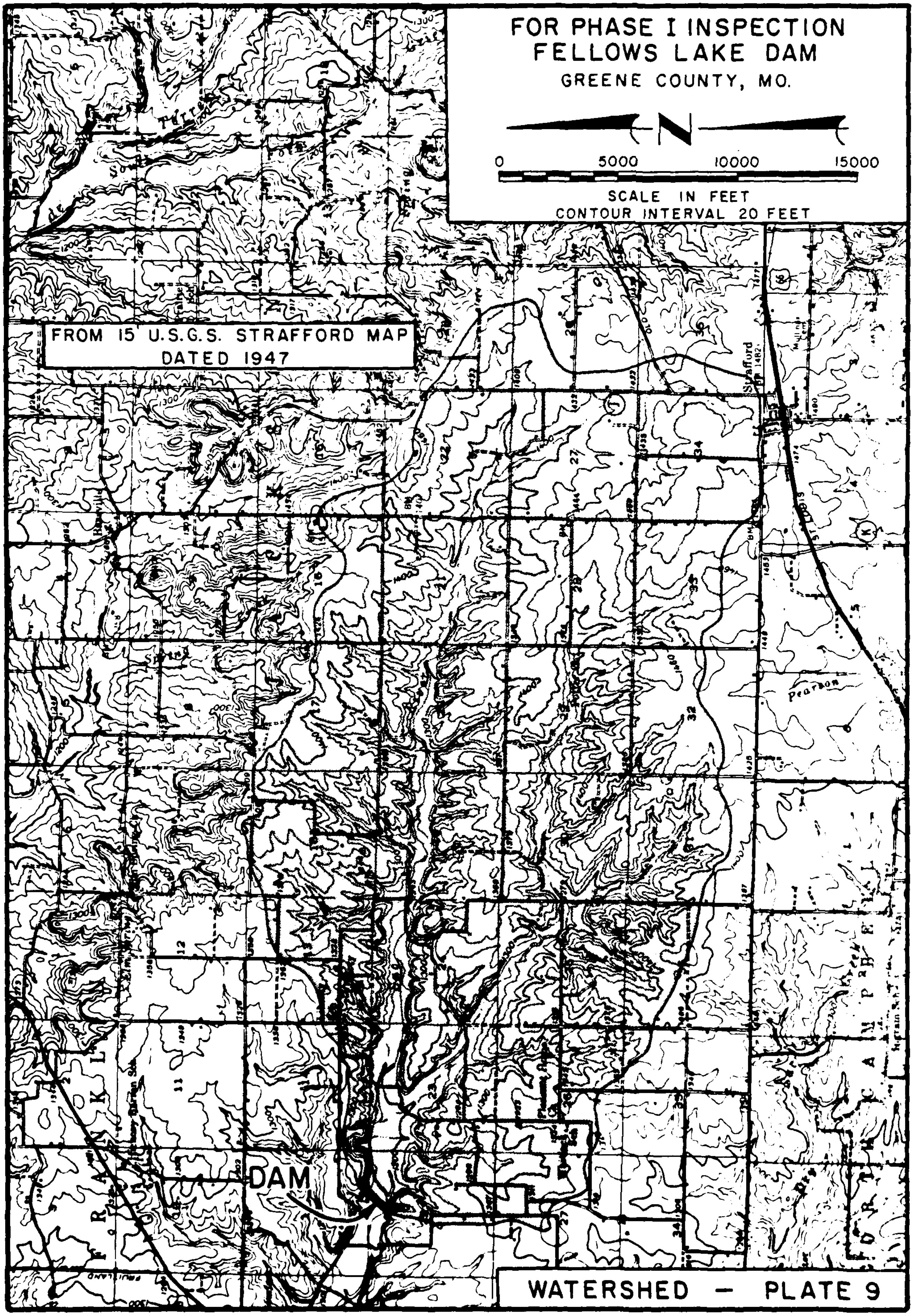
LOCATION OF
OBSERVATION HOLES
FELLOWS LAKE DAM

GAS
WATER

ENG'R. BY:	APP'D BY: JJP	REVISED:	BELL:	SCALE: 1" = 40'
DR. BY: DC & RH	DATE: 2-24-77	MAP NO.:	SHEET OF	DR. NO.: 4837-D

PREPARED BY REITZ & JENS, INC.
FOR A PHASE I DAM INSPECTION

PLATE 8


FOR PHASE I INSPECTION
FELLOWS LAKE DAM
GREENE COUNTY, MO.
N
0
5000
10000
15000
SCALE IN FEET
CONTOUR INTERVAL 20 FEET
FROM 15' U.S.G.S. STRAFFORD MAP
DATED 1947
Strafford
Pearson
DAM
WATERSHED — PLATE 9

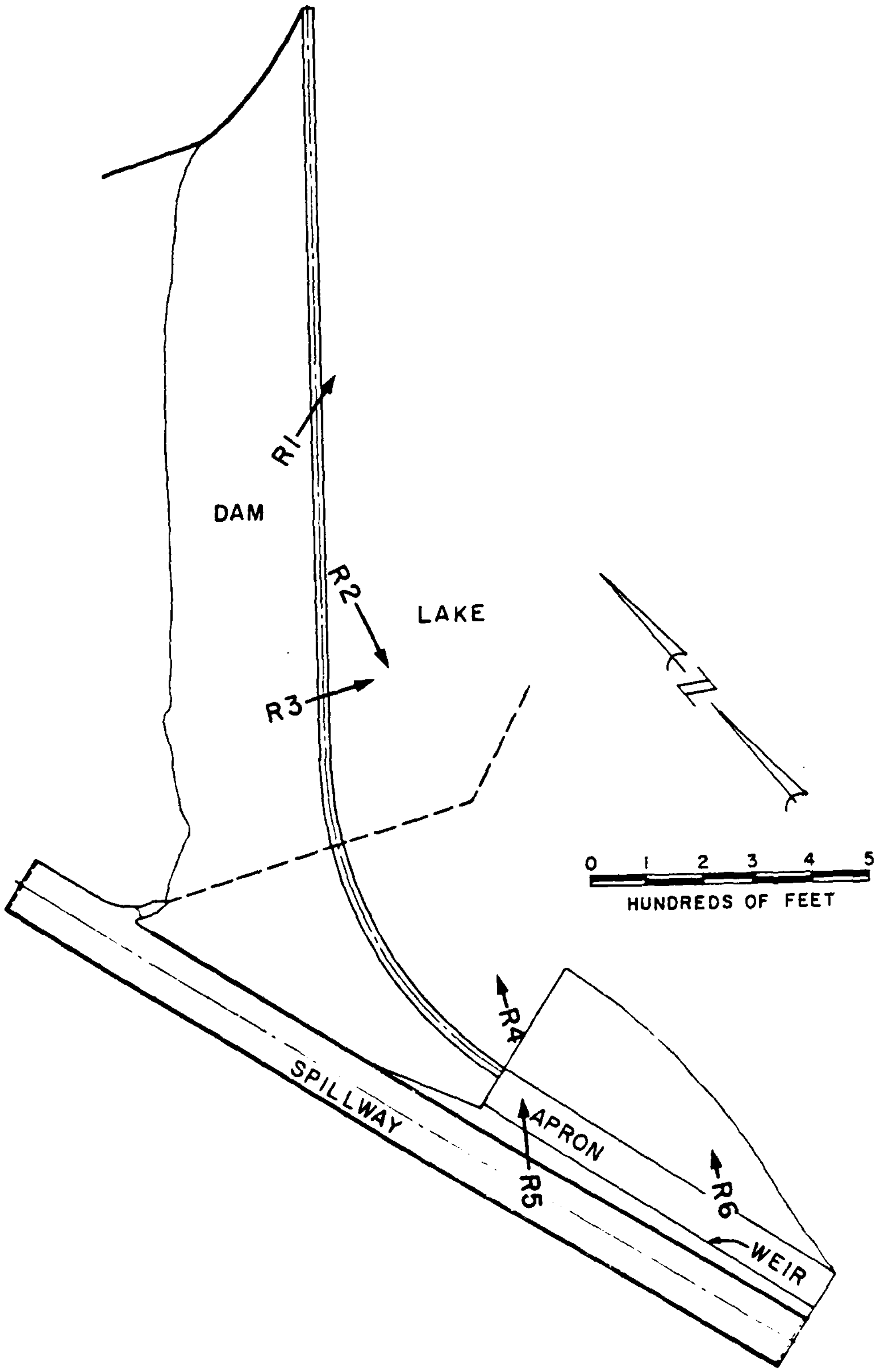


PHOTO INDEX NO. 1
RESERVOIR

FELLOWS DAM
GREENE COUNTY, MO.

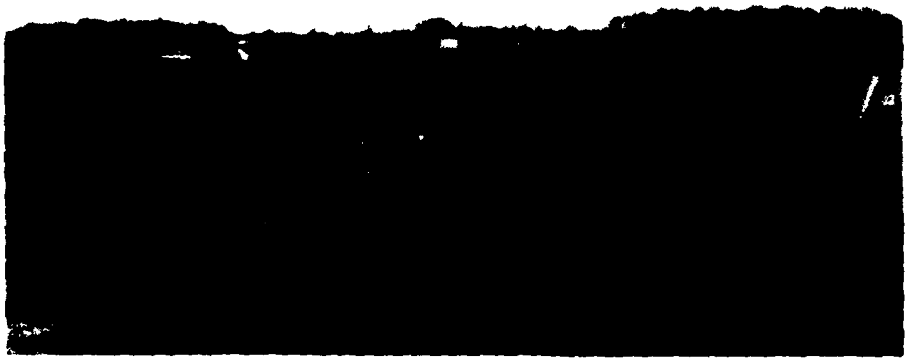
SEPTEMBER 1979

PREPARED BY
REITZ & JENS, INC.

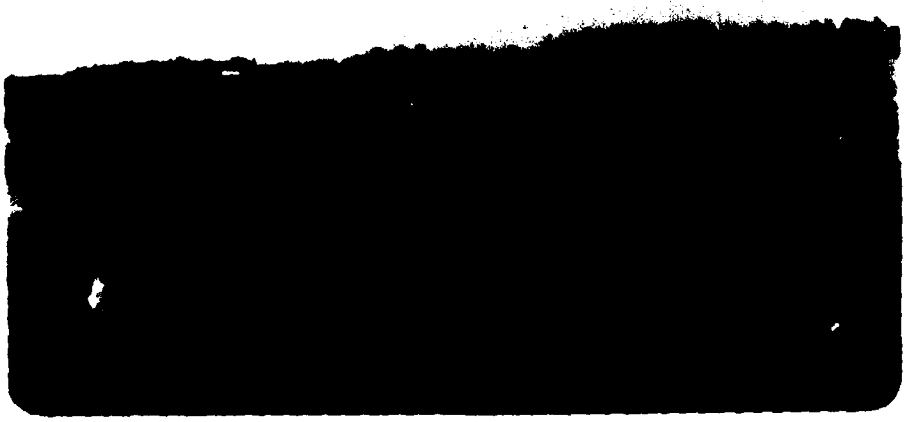
R2

R3

R4



R6



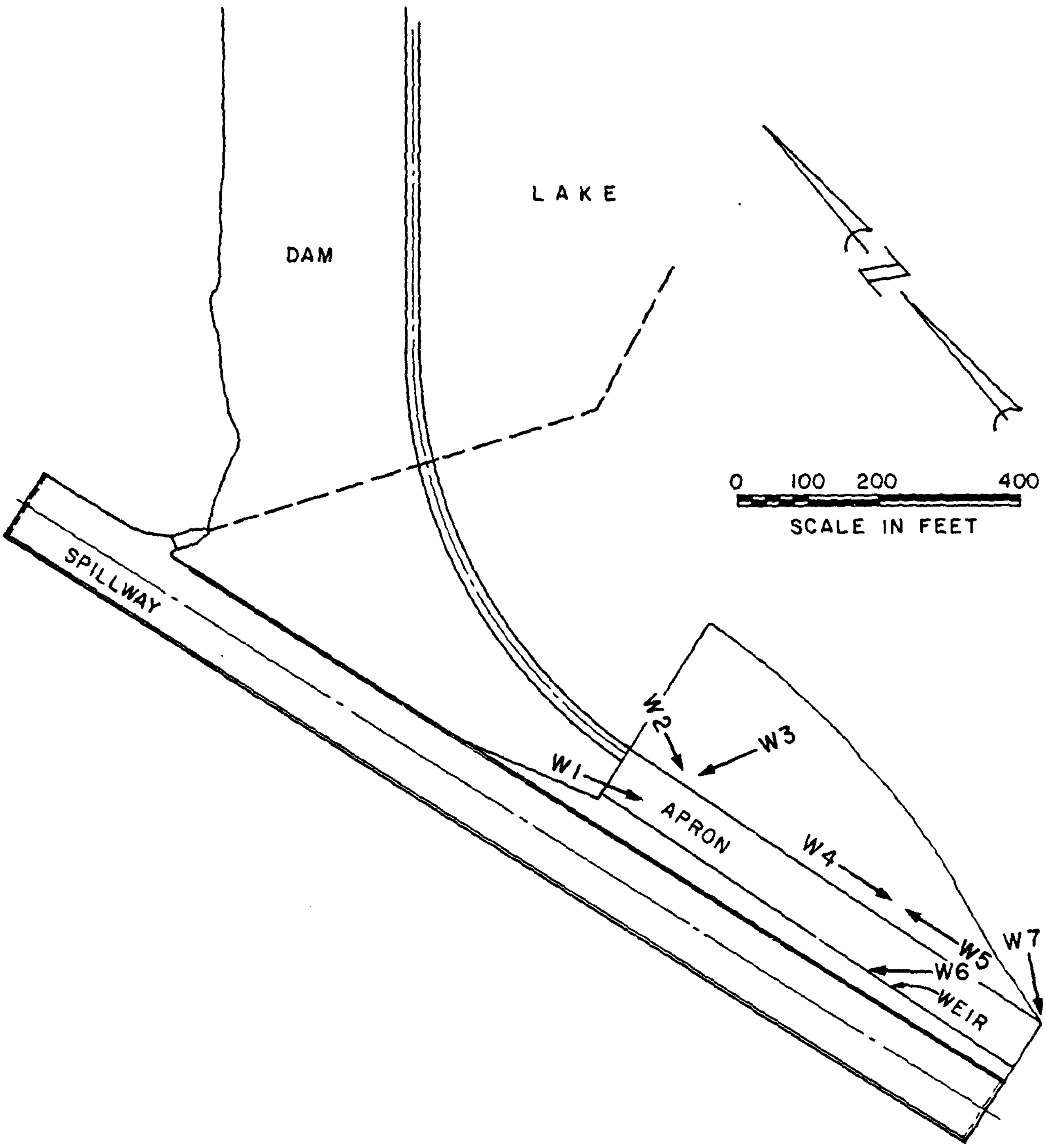


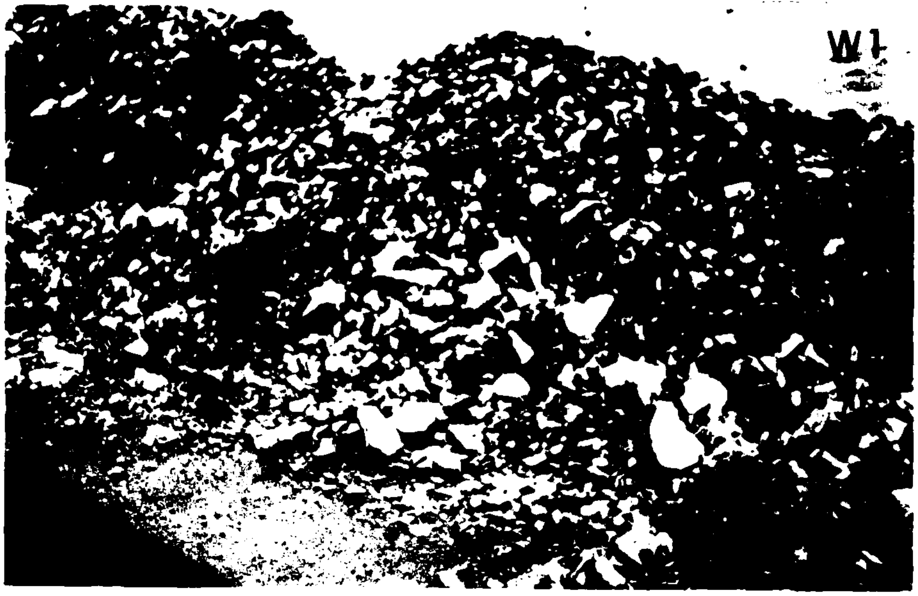
PHOTO INDEX NO. 2
WEIR AND APRON

FELLOWS DAM
GREENE COUNTY, MO.

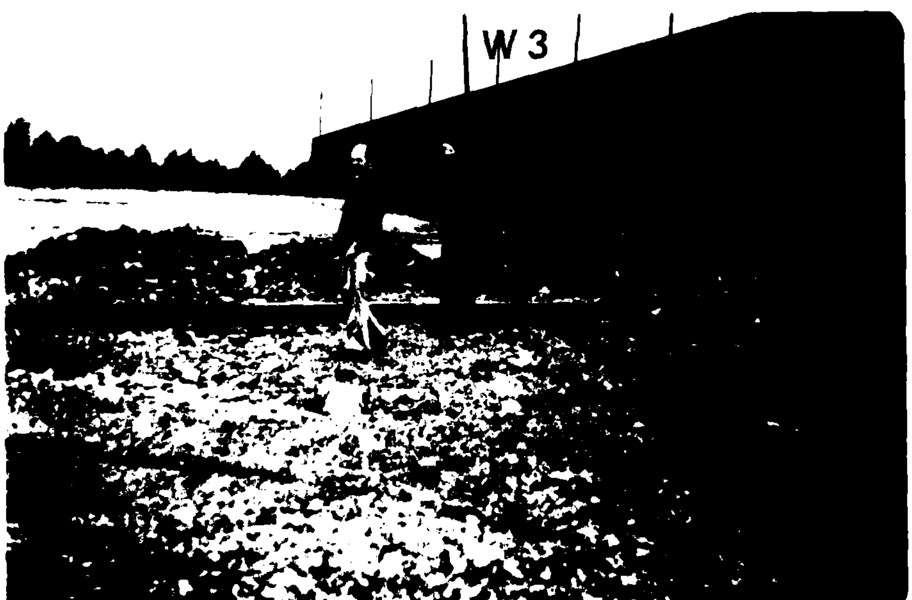
PREPARED BY
REITZ & JENS, INC.

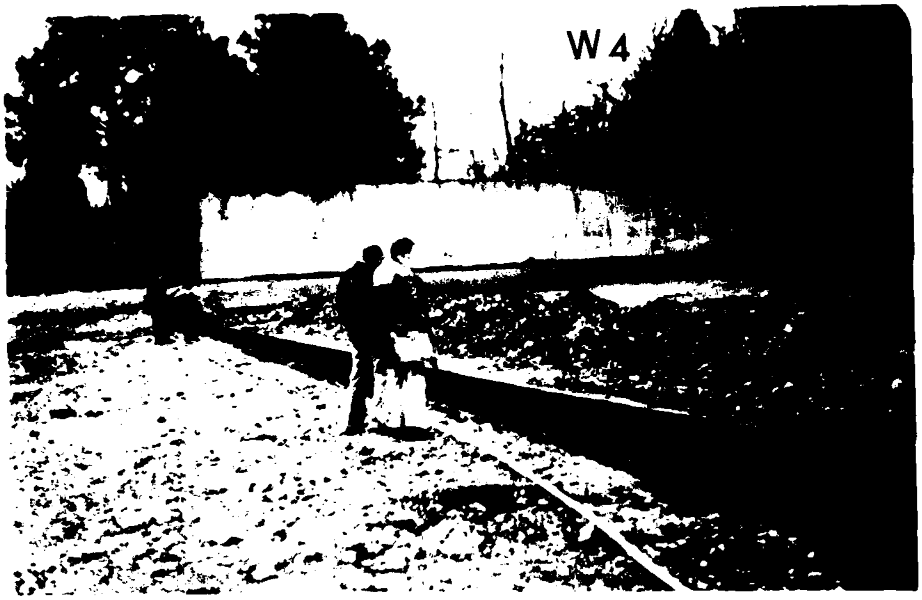
SEPTEMBER 1979

W1

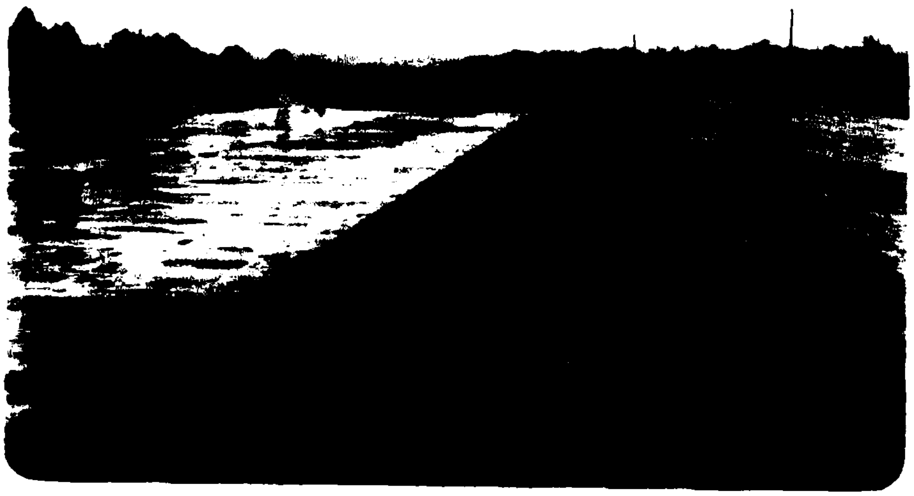


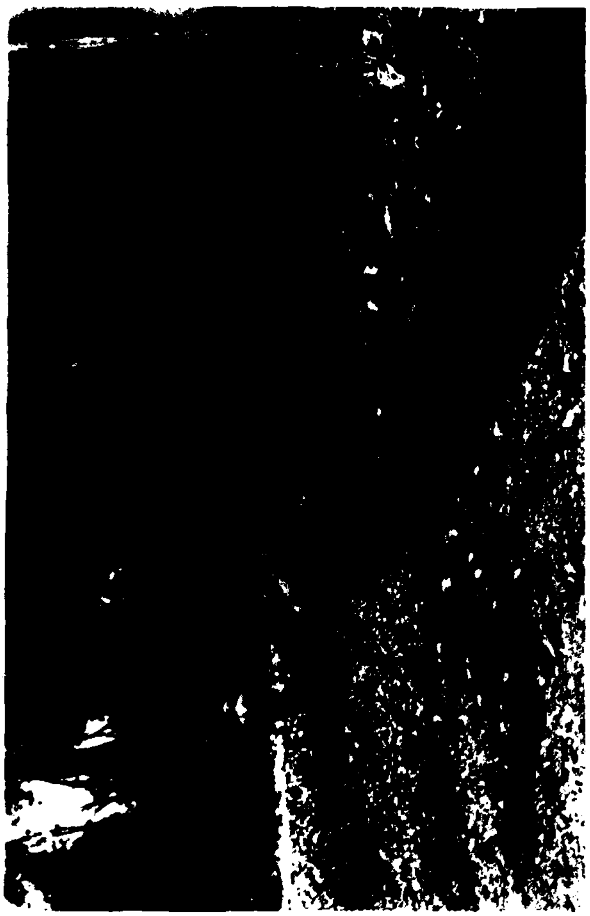
W2





W6





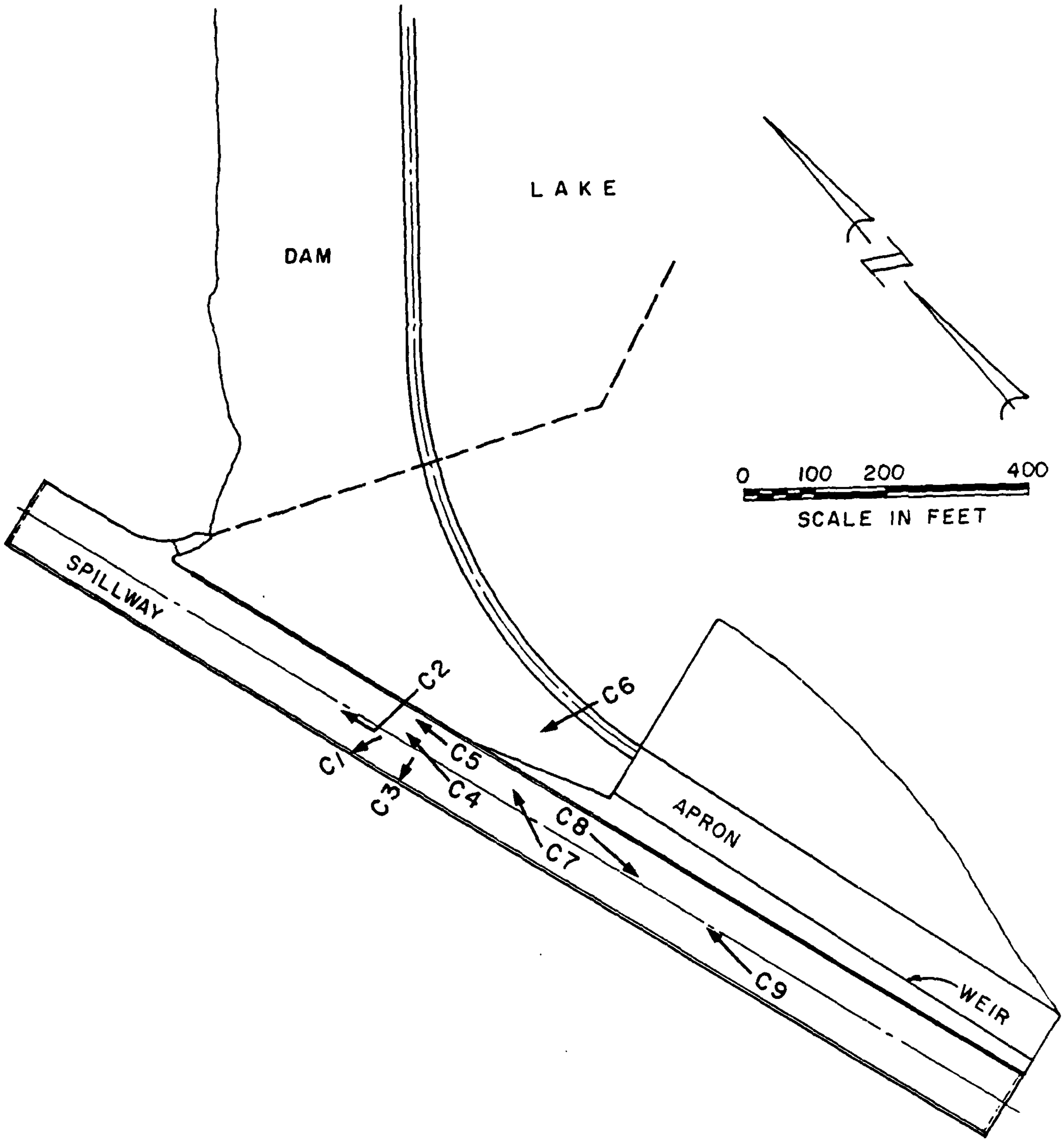


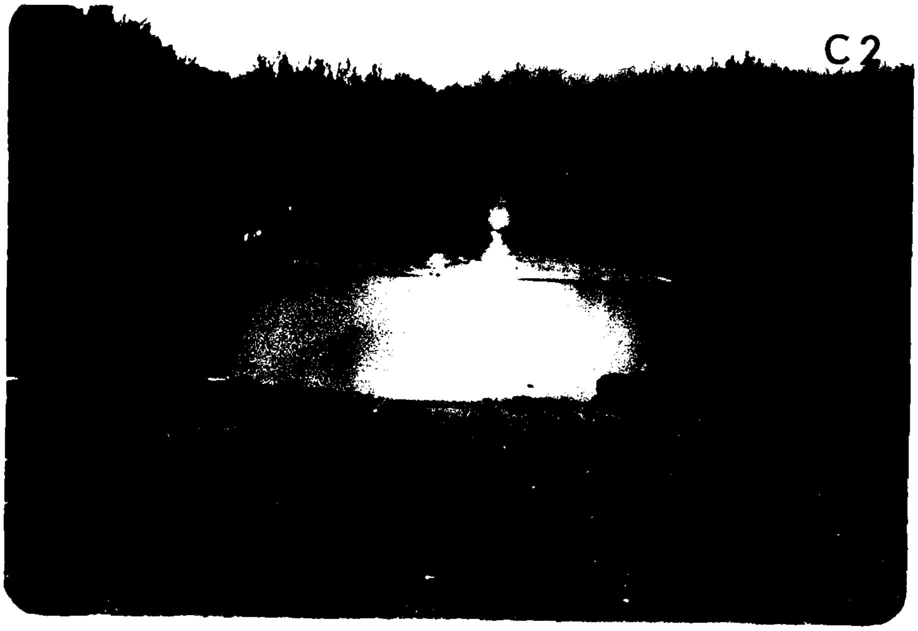
PHOTO INDEX NO. 3
SPILLWAY CHUTE

FELLOWS DAM
GREENE COUNTY, MO.

PREPARED BY
REITZ & JENS, INC.

SEPTEMBER 1979

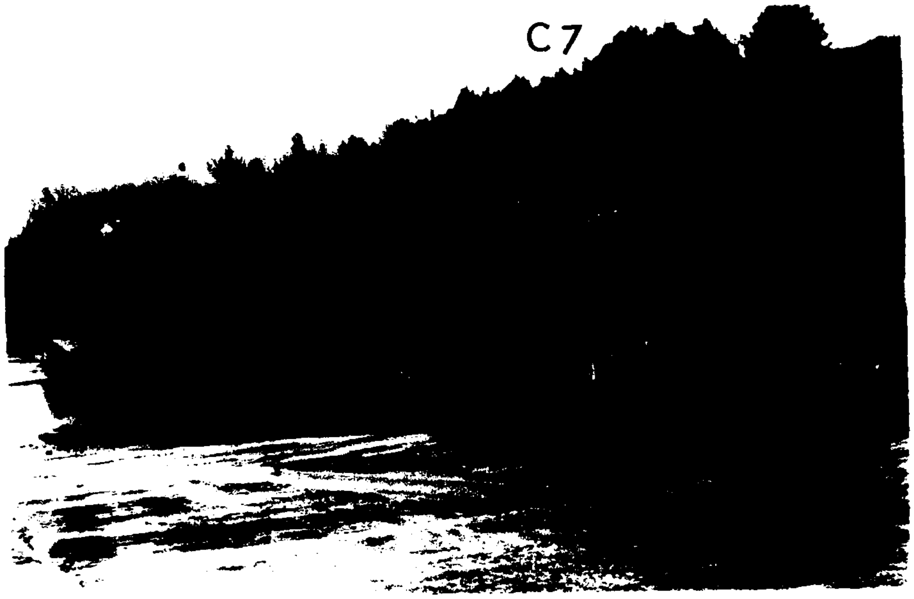

C1


C2

C5

C 6

C7



C8

C9

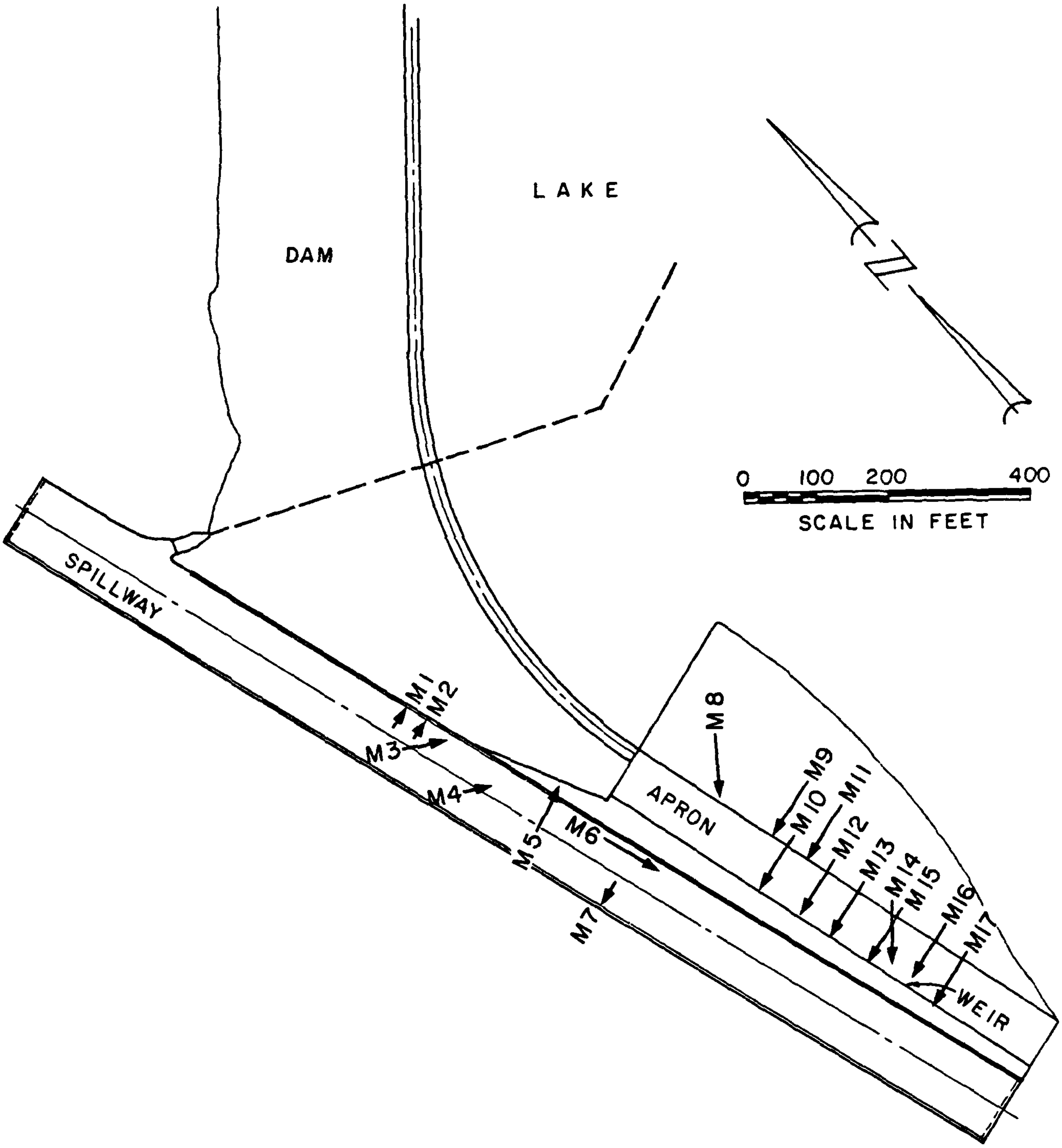
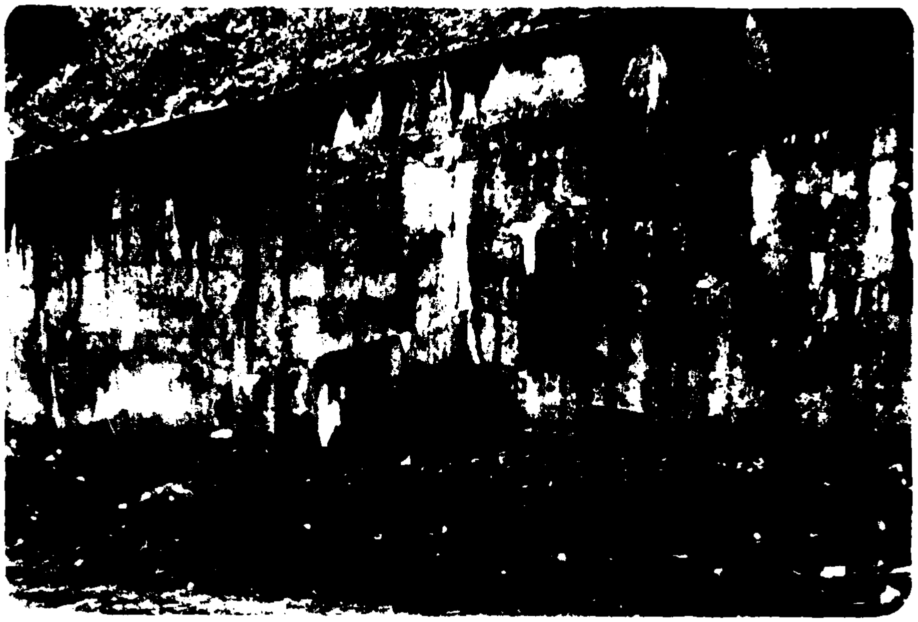


PHOTO INDEX NO. 4
MASONRY DETERIORATION

FELLOWS DAM
GREENE COUNTY, MO.

PREPARED BY
REITZ & JENS, INC.

SEPTEMBER 1979

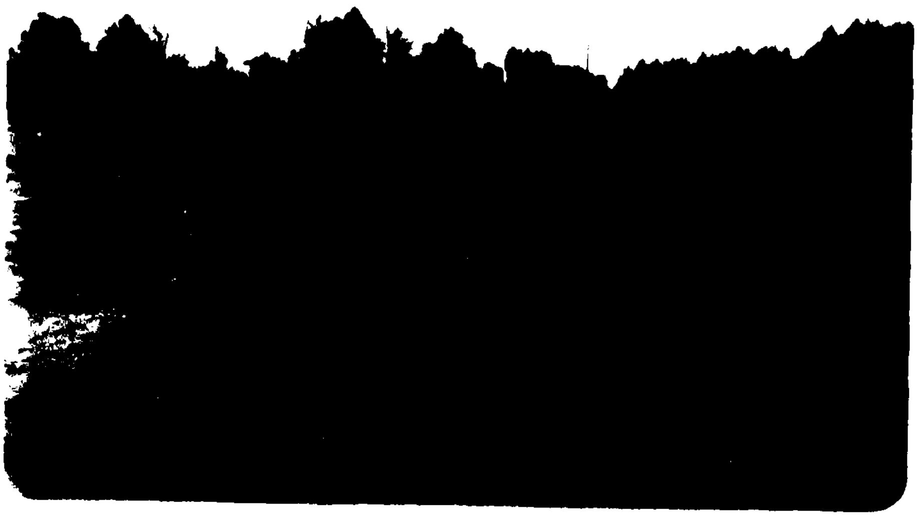


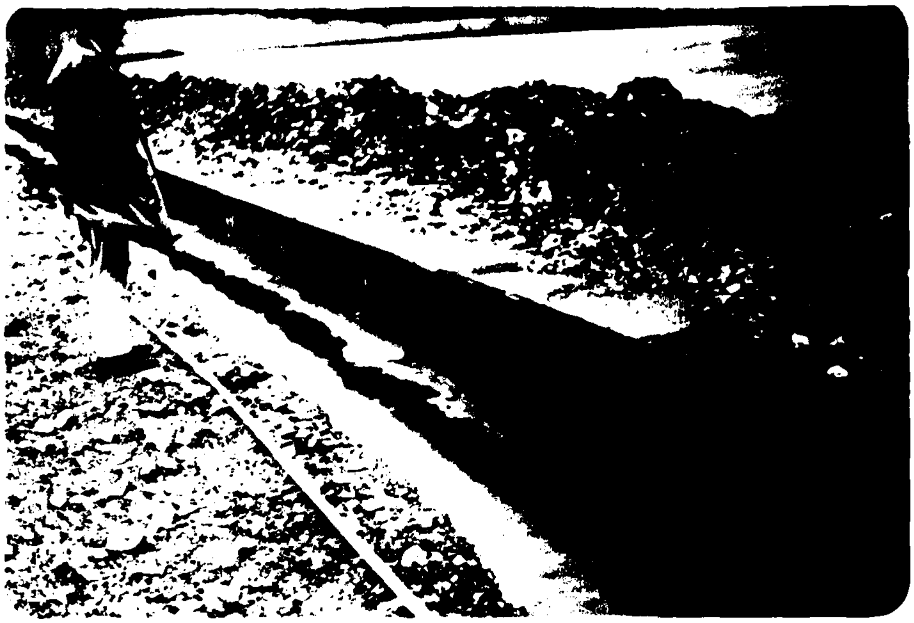
M3

M4

M5

M6



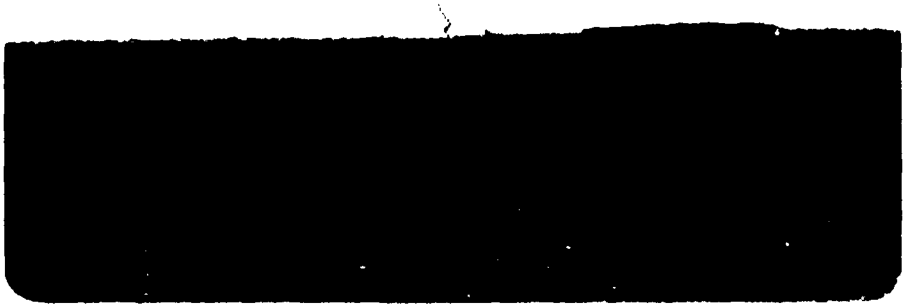



M10

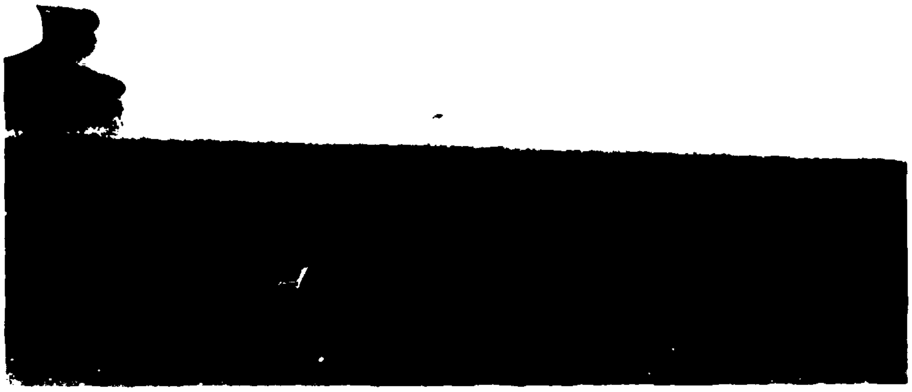

M 12

M13

M15



M16



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O